MANUAL OF PRACTICAL ANATOMY

CUNNINGHAM

PART I.

9/5 (16)

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A MANUAL

OF

PRACTICAL ANATOMY.

PART I.

UPPER LIMB, THORAX, LOWER LIMB.

SECOND EDITION.

A MANUAL

OF

PRACTICAL ANATOMY.

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PART I.

UPPER LIMB, THORAX, LOWER LIMB.

SECOND EDITION,

BY THE AUTHOR,

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EDINBURGH:

MACLACHLAN AND STEWART.

LONDON: SIMPKIN, MARSHALL, AND CO.

1889.

DUBLIN:
PRINTED AT THE UNIVERSITY PRESS,
BY PONSONBY AND WELDRICK.

PREFACE TO THE SECOND EDITION.

THIS volume, as now issued, is virtually a new book; it has been entirely re-written, and greatly enlarged. When it first appeared it was merely a 'Dissector's Guide,' and nothing more. Its sole aim was to give a concise account of the methods of dissection employed in the Edinburgh School of Anatomy, and detailed descriptions of the parts displayed were carefully avoided. It was found, however, that it did not meet the requirements of the case, inasmuch as it was necessary for the Student to be provided with a second book on Practical Anatomy, and the inconvenience of having constantly to refer from one book to the other was very great, and constituted a serious hindrance to the dissector in his practical work. In the preparation of Parts II. and III. the author was consequently induced to change his original plan, and to present to the Student a complete account of the regional Anatomy of the Abdomen, and Head and Neck. Part I., in its present form, stands on a line with these.

It is evident that the former title, 'Dissector's Guide,' hardly indicates the full scope of the book in its altered condition, and it has, therefore, been deemed advisable to change its title to 'A Manual of Practical Anatomy,' which more accurately expresses its aim.

In preparing this *New Edition* of Part I. the author has received great assistance from DR. H. ST. JOHN BROOKS, Chief Demonstrator of Anatomy in Trinity College. In all cases of doubt he verified the descriptions by special dissections. More especially is the author indebted to him for the extreme care with which he tested the accuracy of the account which is given of the relations of the pleura to the thoracic walls.

The author has also to record his thanks to MR. E. H. TAYLOR, B.A., Medical Scholar, for his assistance in correcting the proof-sheets.

The majority of the illustrations are new, and of these several have been drawn by MR. GEORGE HEPENSTALL. A considerable number have also been obtained from the well-known text-books of Gegenbaur, Luschka, &c. In every case the sources from which the latter have been derived are indicated in the text.

43, FITZWILLIAM PLACE, DUBLIN,
August 26, 1889,

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THORAX.

ERRATA.

Page 270, line 7 from below, *for* 'three ribs,' *read* 'true ribs.'

,, 191, line 19 from above, *for* 'opposition,' *read* 'apposition.'

,, 403, line 2 from above, *for* 'upper,' *read* 'posterior.'

,, ,, line 7 from above, *for* 'disposed of in four strata,' *read* 'disposed in four strata.'

A
MANUAL OF PRACTICAL ANATOMY.

UPPER LIMB.

THE dissector of the upper limb begins work on the third day after the subject has been placed in the dissecting-room. He will then find the subject stretched out at full length upon its face, with the pelvis and chest supported by blocks (Fig. 1, p. 3); and while the body remains in this position he must examine those structures which connect the limb to the posterior aspect of the trunk.

Surface Anatomy.—Before proceeding to the actual dissection of any region, the student should make it an invariable rule to familiarize himself with the bony prominences. It is by using these as landmarks that the surgeon is enabled to establish the position of the component parts of the body in the living subject. Their importance can hardly be exaggerated. In the middle line of the back there will be little difficulty in recognizing the spines of the vertebræ, which follow each other in consecutive order. If the finger be passed over them, it will be observed that they do not, in every case, occupy the mesial plane; some of them may be deflected, to a slight degree, to one side or the other. The spines of the vertebræ are the only parts of the vertebral column which come to the surface; they alone yield direct information, by touch, to the surgeon as to the condition of the spine. At the lower end of the neck, the spine of the seventh

cervical vertebra (*vertebra prominens*) makes a visible projection ; and so also do the spines of the first two dorsal vertebræ. As a rule, the most evident of the three is that of the first dorsal vertebra. At a lower level, in subjects of good muscular development, a mesial furrow is produced by the prominence of the erector spinæ muscle on each side ; and the spines may be felt at the bottom of this groove. It attains its greatest depth in the upper part of the lumbar region ; and it fades away below at the level of the spine of the third sacral vertebra. The finger should next be passed along the crest of the ilium as it pursues its sigmoid course forwards and outwards. Note that the posterior superior spine of the ilium lies in a slight depression above and to the outer side of the third sacral spine. The scapula is for the most part thickly covered by muscles ; but, in spite of this, in the majority of cases its general outline can be made out. It is very mobile—moving more or less with every movement of the limb. The spine and acromion process of the scapula will be seen to be subcutaneous throughout. It is important to make out accurately the angle which is formed by the meeting of the lower border of the spine with the outer margin of the acromion. This very apparent bony point is selected as the upper limit in making measurements of the limb.

DISSECTION OF THE BACK.

In this dissection the following are the parts which require to be examined :—

1. The cutaneous vessels and nerves of the back.
*2. The trapezius muscle.
3. The latissimus dorsi muscle.
4. The rhomboid muscles and their nerve of supply.
*5. The levator anguli scapulæ muscle.

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* The structures in the above list which are marked with an asterisk belong alike to the dissectors of the head and neck and the upper limb.

*6. The spinal accessory nerve, and the nerves from the cervical plexus which supply the trapezius.
7. The transversalis colli artery and its two terminal branches (viz. the posterior scapular and the superficial cervical).
8. The posterior belly of the omo-hyoid muscle.
*9. The suprascapular artery and nerve.

This dissection must be completed *in two days*, in order that the dissector of the head and neck may be enabled to continue the deeper dissection of the back. The *first day's work* should comprise—(1) the reflection of the skin; (2) the dissection of the cutaneous nerves and vessels; and (3) the cleaning of the latissimus dorsi and trapezius muscles. The remainder of the dissection can be undertaken on *the second day*.

Reflection of the Skin.—The following incisions are necessary:—1. From the tip of the coccyx upwards, along the middle line of the body to the spine of the seventh

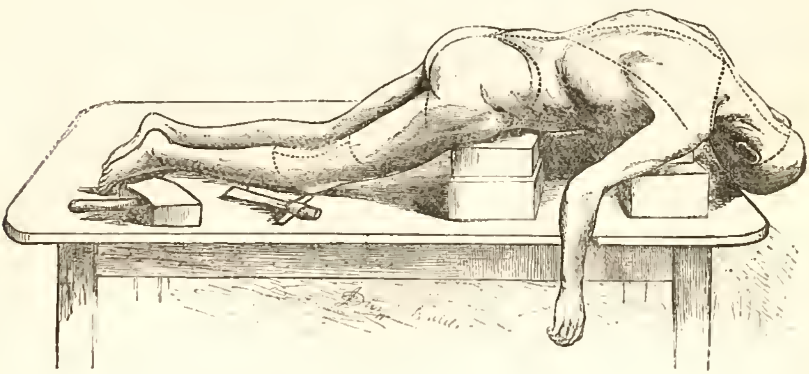

FIG. 1.

cervical vertebra. 2. From the upper end of the foregoing mesial incision transversely outwards, to the inner

* The structures in the above list, which are marked with an asterisk, belong alike to the dissectors of the head and neck and the upper limb.

border of the acromion process of the scapula. 3. From the lower extremity of the mesial incision in a curved direction outwards and forwards, along the crest of the ilium, to within two inches of the anterior superior iliac spine. 4. An oblique incision from the spine of the first lumbar vertebra, upwards and outwards, to the outer border of the acromion process. The two large flaps which are now mapped out upon the back must be carefully raised from the subjacent fatty tissue. Reflect the upper triangular flap first, and then deal in the same way with the lower flap.

Superficial Fascia.—The fatty layer which is now exposed is termed the *superficial fascia.* It constitutes the cushion upon which the skin rests, rounds off the angularities of the body, and varies in thickness according to the obesity of the subject. In subjects that have lain for some time on the back it is usually more or less infiltrated, in this region, with fluid which has gradually gravitated into its loose meshes. The superficial fascia constitutes the bed in which the cutaneous vessels and nerves ramify before they enter the skin; and it is separated from the muscles by a tough, but thin, layer of fibrous tissue, devoid of fat, which forms an investment for the body. This aponeurotic membrane receives the name of the *deep fascia;* and it can be readily demonstrated by making an incision in the superficial fascia, and raising a small portion of it.

Cutaneous Vessels and Nerves.—In searching for a cutaneous nerve, cut boldly down through the superficial fascia in the direction in which the nerve runs, until the plane at which the superficial and deep fasciæ blend is reached. It is here that the main trunks are to be found; and in a well injected subject the cutaneous arteries constitute the best guides. A more rapid way of finding the cutaneous nerves in this region is to reflect both fasciæ

outwards from the vertebral spines. The nerves are seen piercing the muscles. This plan, however, should only be adopted by the senior student.

The *cutaneous nerves* of the back are derived from the posterior primary divisions of the spinal nerves. As the latter pass backwards, they divide into external and internal branches. Both of these supply twigs to the muscles amongst which they lie; but one or other also contains some sensory fibres which come to the surface to supply the skin. Thus the *upper six or seven* cutaneous nerves in the *dorsal region* are the terminations of the internal branches of the posterior primary divisions of the spinal nerves. They become superficial close to the vertebral spines, and are to be sought for near the mesial plane. It is not uncommon to find one or more of them piercing the trapezius one or two inches external to the line of emergence of the others. The branch which comes from the second dorsal nerve is the largest of the series; and it may be traced outwards beyond the spine of the scapula. The *lower five or six* cutaneous nerves in the *dorsal region* are the terminal twigs of the external branches of the posterior primary divisions of the spinal nerves; and, consequently, they must be looked for at a short distance from the middle line of the back. They reach the surface by piercing the latissimus dorsi muscle on a line with the angles of the ribs and outer margin of the erector spinæ muscle. In every case the cutaneous branches derived from the dorsal nerves turn outwards in the superficial fascia, and may be traced for a varying distance in this direction.

In the *lumbar region* three cutaneous nerves reach the surface by piercing the lumbar aponeurosis at the outer margin of the erector spinæ, a short distance above the ilium. They are the terminal twigs of the external branches of the posterior primary divisions of the three upper lumbar spinal nerves; and they differ from those above, inasmuch as they turn downwards over the crest of the ilium to supply the skin of the gluteal region.

The *cutaneous arteries* which accompany these nerves come from the dorsal branches of the intercostal and lumbar arteries.

Trapezius Muscle.—The trapezius should now be cleaned. This muscle belongs only in part to the dissector of the upper limb. The portion of it which lies above the prominent spine of the seventh cervical vertebra is the property of the dissector of the head and neck, and must be dissected by him. Let the two dissectors work in conjunction with each other; and when the entire muscle is exposed, let each give the other an opportunity of studying it in its entirety.

In cleaning the trapezius the limb must be placed in such a position as will render the fibres of the muscle tense. If the dissection is being made on the *right* side, the arm must be placed close to the trunk, and drawn downwards, whilst the scapula is dragged well forwards over the side of the block which supports the chest. A transverse cut is now to be made through the superficial and deep fasciæ, from the seventh cervical spine outwards. This incision will be found to coincide with the direction of the fibres at this level. From this point gradually work downwards, raising both fasciæ in a continuous layer from the surface of the muscle. The knife must always be carried in the direction of the muscular fibres; and care must be taken to leave none of the thin, filmy, deep fascia behind. If this rule be attended to, it will be found that, as the dissection progresses, the knife is not, as at first, carried transversely, but obliquely, in accordance with the direction of the fibres of the lower portion of the muscle. When this stage is reached, a change in the position of the arm is required in order that the lower oblique fibres may be stretched to the full extent. The scapula must still be kept as far forwards as possible; but the limb must be carried upwards, and placed parallel to the neck. In the case of the *left* trapezius, the

student must make the incision through the fascia, along the lower margin of the muscle, and work upwards to the level of the seventh cervical vertebra. In the first instance the limb must be extended, and, at a later stage, placed by the side, as the transverse fibres of the muscle are reached. In removing the fascia from the trapezius, and indeed throughout the whole dissection of the back, the cutaneous nerves must be carefully preserved, in order that the dissector of the head and neck may have an opportunity of establishing their continuity with the trunks from which they arise.

The *trapezius* is a flat, triangular muscle, which is immediately subjacent to the deep fascia in its entire extent. It has a very wide origin, which extends along the mesial plane, from the occiput above to the level of the last dorsal vertebra below. It arises from—(1) the inner third or less of the superior curved line of the occipital bone and the external occipital protuberance; (2) the ligamentum nuchæ and the spine of the seventh cervical vertebra; (3) the tips of the spines of all the dorsal vertebræ, as well as the supraspinous ligaments which bridge across the intervals between these. The *cranial* or *occipital* origin is by short tendinous fibres, which are interlaced with aponeurotic bands, connecting it to the adjacent attachment of the sterno-mastoid. The *cervical* and *dorsal* origin is, for the most part, also effected by short tendinous fibres, which are not very apparent, owing to the fact that they are almost immediately replaced by the fleshy fasciculi; but in the lower cervical and upper dorsal regions they lengthen out so as to form a manifest flat tendon, which, taken in conjunction with the corresponding aponeurosis of the opposite side, exhibits an oval outline. As the fibres of the trapezius pass outwards, they converge to gain an insertion into the two bones of the shoulder-girdle. The occipital and upper cervical fibres incline downwards, and turning forwards over the shoulder, are inserted into the outer third of the posterior border of the clavicle; the lower cervical and upper dorsal fibres pass more or less transversely outwards, to gain an insertion

into the inner border of the acromion process and the upper margin of the spine of the scapula ; while the lower dorsal fibres are directed upwards, and at the base of the scapula end in a flat, triangular tendon, which plays over the smooth surface at the root of the scapular spine, and is inserted into a rough tubercle on the scapular spine immediately beyond this. To facilitate the movement of the tendon upon the bone a small synovial bursa intervenes between them.

Latissimus Dorsi.—The latissimus dorsi is a wide, flat muscle, which covers the back from the level of the sixth dorsal vertebra down to the crest of the ilium. Above it is overlapped by the trapezius ; but, in its greater part, it is subcutaneous. It is a difficult muscle to clean, not only on account of the varying direction of its fibres, but also because its upper part is generally very thin, and its upper border ill-defined. Both layers of fascia should be raised together from its surface, and its fibres may be stretched by raising the arm and folding it under the chest. The origin of the latissimus dorsi in the lumbar region is effected through the medium of the superficial lamina of the lumbar fascia, a dense tendinous aponeurosis, which covers the erector spinæ in the loins (Fig. 2). Clean this structure thoroughly. The attachment of the muscle to the crest of the ilium, and its slips of origin from the lower ribs, must be carefully defined ; and, at the same time, the posterior and lower part of the external oblique muscle of the abdomen should be cleaned, so that its relation to the latissimus dorsi may be studied. As the latissimus dorsi sweeps over the inferior angle of the scapula it receives an accession of fibres from that bone. This fleshy slip may be brought into view when the muscle is cleaned by relieving the tension of the muscular fibres, and then turning the upper margin of the muscle outwards. It is apt to be mistaken for a piece of the teres major muscle upon which it lies.

The *latissimus dorsi* arises—(1) from the tips of the spinous processes of the lower six dorsal vertebræ and the supraspinous ligaments in connexion with them; (2) from the superficial lamella of the lumbar fascia (Fig. 2); (3) by a thin tendinous origin from a small extent of the outer lip of the crest of the ilium in front of the lumbar fascia; (4) by three or four digitations from the lower three or four ribs; and (5) by a fleshy slip from the dorsal aspect

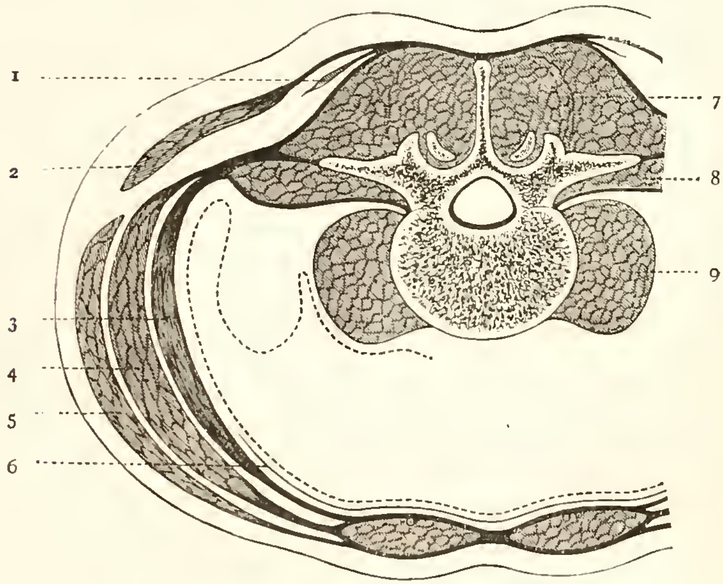

FIG. 2.

Diagram of the Lumbar Fascia.

1. Serratus posticus inferior.
2. Latissimus dorsi.
3. Transversalis abdominis.
4. Obliquus internus.
5. Obliquus externus.
6. Fascia transversalis.
7. Erector spinae.
8. Quadratus lumborum.
9. Psoas.

of the inferior angle of the scapula. By means of its origin from the posterior lamella of lumbar fascia, it receives an indirect attachment to the spines of the lumbar and upper sacral vertebræ, and also to the posterior part of the crest of the ilium. The costal slips of origin inter-

digitate with the lower digitations of the external oblique muscle of the abdominal wall.

The fibres of the latissimus dorsi converge rapidly as they approach the lower part of the scapula. The highest fibres pass almost horizontally outwards towards this point; the lowest fibres ascend almost vertically; whilst the intermediate fibres show varying degrees of obliquity. As a result of this convergence of fibres, the muscle is greatly reduced in width; and it sweeps over the inferior angle of the scapula in the form of a thick, fleshy band, which winds round the lower margin of the teres major muscle, to gain insertion, by means of a narrow, flat tendon, into the bottom of the bicipital groove of the humerus. This insertion cannot be studied at present, but will be seen later on (p. 57). With the teres major, the latissimus dorsi forms the posterior fold of the axilla. At first, on the dorsal aspect of the teres major, the latissimus dorsi is folded round its lower border, and finally at its insertion comes to lie in front of it. To this peculiar relationship of the two muscles is due the full, rounded appearance of the posterior axillary fold.

A *triangular space* mapped out by the lower border of the trapezius, the upper border of the latissimus dorsi, and the base of the scapula, will now be noticed. Within these limits a small portion of the rhomboideus major will be seen, and also a varying amount of the chest-wall—a part corresponding to the sixth intercostal space and the borders of the ribs which bound it above and below. It is well to note that this is the only part of the thoracic parietes which is uncovered by muscles. Further, between the last rib and the crest of the ilium the anterior border of the latissimus dorsi will generally be observed to overlap the posterior border of the external oblique muscle of the abdominal wall. Sometimes, however, a narrow triangular interval exists between the two muscles, in which is seen a small part of the internal oblique muscle.

Reflection of the Trapezius.—On the *second day* the dissector should begin by reflecting the trapezius. This should be done, if possible, in conjunction with the dissector of the head and neck. Divide the muscle about two inches from the spines of the vertebræ, and throw it outwards towards its insertion. The trapezius is very thin at its origin, and the greatest care must therefore be taken not to injure the subjacent rhomboid muscles. The small *bursa* between the tendon of insertion of the lower part of the trapezius and the triangular root of the spine of the scapula must not be overlooked.

A dissection of the deep surface of the reflected muscle will reveal the following structures:—

a. The spinal accessory nerve.
b. Two or three nerves from the cervical plexus.
c. The superficial cervical artery.

These constitute the nervous and vascular supply of the trapezius.

The nerves have already been displayed by the dissector of the head and neck, as they cross the posterior triangle of the neck. The branches from the cervical plexus come from the third and fourth cervical nerves. On the deep surface of the trapezius they join with branches of the spinal accessory to form the *subtrapezial plexus*, from which twigs proceed into the substance of the muscle. The terminal twigs of the spinal accessory nerve can be traced nearly to the lower margin of the trapezius.

The *superficial cervical artery* which accompanies the spinal accessory nerve must be followed to the anterior border of the trapezius, where it will be seen to spring from the *transversalis colli artery*.

Omo-hyoid.—Suprascapular Artery and Nerve.—The posterior belly of the omo-hyoid and the suprascapular artery and nerve can now be displayed by dissecting towards the upper margin of the scapula, and removing

carefully the loose fatty tissue in this locality. The dissector of the head and neck must take part in this dissection, and it is well not to expose these structures for more than an inch from the upper margin of the scapula.

The slender *posterior belly of the omo-hyoid* muscle will be seen to arise from the upper border of the scapula immediately behind the suprascapular notch. It also derives fibres from the ligament which bridges across this notch. The *suprascapular artery* will be noticed to enter the supraspinous fossa of the scapula by passing over the suprascapular ligament, whilst the *suprascapular nerve* proceeds into the fossa under cover of the ligament.

The Rhomboid Muscles constitute a thin quadrangular sheet of muscular fibres, which proceeds from the spinous processes of the vertebræ to the base of the scapula. Draw the scapula well over the edge of the block which supports the chest of the subject. The fibres are thus rendered tense, and the cleaning of the muscles greatly facilitated. The *nerve to the rhomboids* should be secured at this stage, so that it may be preserved from injury in the further dissection of the region. It can best be detected by dissecting in the interval between the rhomboideus minor and the levator anguli scapulæ about one inch to the inner side of the superior angle of the scapula. It is accompanied by the posterior scapular artery, and it will afterwards be traced upon the deep surface of the rhomboid muscles when they are reflected.

The *rhomboideus minor* is a narrow, ribbon-like fleshy band which runs parallel to the upper border of the greater rhomboid. It springs from the lower part of the ligamentum nuchæ, the spine of the seventh cervical vertebra, and frequently also from the spine of the first dorsal vertebra, and it is inserted into the base of the scapula opposite the triangular surface at the root of its spine. It is entirely covered by the trapezius.

The *rhomboideus major* arises from the upper four or

five dorsal spines, and the corresponding part of the supraspinous ligament. Its fibres run obliquely downwards and outwards, and end in a tendinous cord, which receives insertion into the base of the scapula close to the inferior angle From this point, up to the commencement of the spine, the tendinous cord is firmly bound to the base of the scapula by areolar tissue. The greater part of the rhomboideus major is covered by the trapezius; only a small portion near the inferior angle of the scapula is immediately subjacent to the deep fascia.

The Levator Anguli Scapulæ is an elongated muscle which arises by four slips from the posterior tubercles of the transverse processes of the upper four cervical vertebræ, and passes downwards and backwards to be inserted into the base of the scapula from the superior angle to the spine. In cleaning this muscle care must be taken of the nerves which pass to it from the cervical plexus, and also of the nerve to the rhomboids and the posterior scapular artery which lie under cover of it. The dissector of the head and neck has an interest in the levator anguli scapulæ, and when it has been studied by both dissectors it should be divided midway between its origin and insertion, and the lower portion turned outwards.

Nerve to the Rhomboids and Posterior Scapular Artery.—The nerve to the rhomboids has already been secured in the interval between the rhomboideus minor and the levator anguli scapulæ, and it has still further been exposed by the reflection of the latter muscle. It may now be displayed in its whole length, together with the posterior scapular artery, which it accompanies, by reflecting the rhomboid muscles. These should be detached from the ligamentum nuchæ and the vertebral spines, and thrown outwards towards the base of the scapula. In doing this take care of the serratus posticus

superior, a thin muscle which lies subjacent, and is apt to be injured.

The *nerve to the rhomboids* is a long slender twig which springs from the fifth cervical nerve, usually in common with the upper root of the nerve of Bell. It pierces the scalenus medius, and then proceeds downwards under cover of the levator anguli scapulæ to the deep surface of the rhomboid muscles to which it is distributed. The nerve to the rhomboids likewise supplies one or two twigs to the levator anguli scapulæ.*

The *posterior scapular artery* is a branch of the transversalis colli, and takes origin close to the outer margin of the levator anguli scapulæ. At first it proceeds backwards under cover of this muscle, but soon changing its direction it runs downwards along the base or vertebral border of the scapula under cover of the rhomboid muscles. It gives numerous branches to both ventral and dorsal aspects of the scapula, and its terminal twigs may enter the latissimus dorsi. One large branch usually passes backwards in the interval between the rhomboid muscles, or through the greater rhomboid, to reach the trapezius muscle, and another branch, the *supraspinal*, is given to the supraspinatus muscle, and the structures superficial to it.†

Reflection of Latissimus Dorsi.—Divide the muscle by carrying the knife from its upper margin, about three inches from the vertebral spines, obliquely downwards and backwards to a point a little way behind its digitation from the last rib. In raising the inner portion of the

* The nerve to the rhomboids sometimes pierces the levator anguli scapulæ in two or more branches, which unite in a plexiform manner.

† The posterior scapular artery very frequently arises directly from the third part of the subclavian. This origin was noted in sixteen out of twenty-seven cases recently examined in the Dissecting-room of Trinity College, Dublin.

muscle care must be taken of the subjacent serratus posticus inferior. The attachment of the latissimus dorsi to the crest of the ilium and to the lumbar aponeurosis can now be verified. The outer part of the muscle is next to be thrown forwards, so that the three costal digitations may be seen from their deep aspect, and also for the purpose of displaying the termination of the *subscapular artery* and the *long subscapular nerve*. These are found upon the deep surface of the muscle at the inferior angle of the scapula.

Lastly, replace the outer portion of the latissimus dorsi muscle, and fix it in position by a stitch or two around one or more of the ribs. This is done so as to preserve the posterior fold of the axilla.

The dissector of the arm now stops work for two days. He has completed the dissection of all the dorsal structures which are allotted to him, and he has nothing further to do until the body is turned.

PECTORAL REGION AND AXILLARY SPACE.

On resuming work the dissector will find the body lying upon its back. The chest is raised to a convenient height by means of blocks. A long board is placed under the shoulders for the purpose of supporting the arms when they are abducted from the sides (Fig. 3, p. 19).

In dissecting the axilla and chest it will be found advantageous if the dissectors of the arm and head and neck arrange to work at different hours. The latter at this stage is engaged at the posterior triangle of the neck, and this dissection cannot be well done unless the arm be placed close to the side and the shoulder depressed. For the dissection of the axilla the arm should be stretched out at right angles to the chest. A compromise between these two positions always results in discomfort to both dissectors.

In the dissection of the pectoral region and the axillary space the student meets with the following structures:—

1. Superficial fascia.
2. Cutaneous nerves.
3. Mammary gland.
4. Deep fascia—Axillary fascia.
5. Muscles which enter into the formation of the walls of the axilla:
    - *a.* Pectoralis major.
    - *b.* Pectoralis minor.
    - *c.* Subscapularis.
    - *d.* Teres major.
    - *e.* Latissimus dorsi.
    - *f.* Coraco-brachialis.
    - *g.* Serratus magnus.
6. Costo-coracoid membrane.
7. Cephalic vein.
8. Subclavius muscle.
9. Nerve to the subclavius.
10. Brachial plexus and certain of the branches which proceed from it.
11. Intercosto-humeral nerve.
12. The nerve of Bell.
13. The axillary vessels and their branches.
14. Lymphatic glands.

Four Days are allowed for this dissection. The arm must then be removed, so as to allow the dissector of the thorax to commence the dissection of the thoracic wall. The following Table may be found useful in regulating the amount of work which should be undertaken each day:—

First Day.—(*a*) External Anatomy; (*b*) reflection of skin; (*c*) cutaneous vessels and nerves of the chest, both on its anterior and lateral aspects; (*d*) cleaning of the pectoralis major; (*e*) reflection of the axillary fascia; (*f*) cleaning of that part of the serratus magnus which lies below the fourth rib.

Second Day.—Dissection of the axillary space from below. This includes the boundaries and contents of the space, in so far as they can be got at without the reflection of any muscle.

Third Day.—(*a*) Reflection of the clavicular portion of the pectoralis major; (*b*) the costo-coracoid membrane and the structures piercing it; (*c*) removal of the membrane; (*d*) the dissection of the upper part of the axilla; (*e*) reflection of the sternal part of the pectoralis major.

Fourth Day.—(*a*) Reflection of pectoralis minor; (*b*) general revision of the space and study of the axillary vessels and nerves; (*c*) removal of the middle third of clavicle; (*d*) subclavius muscle; (*e*) brachial plexus; (*f*) nerve of Bell and serratus magnus muscle; (*g*) separation of limb from the trunk.

PECTORAL REGION.

Surface Anatomy.—The entire length of the clavicle can be felt under the skin, and as the student follows its curves with his finger, he can recognize the origins of the pectoralis major and deltoid muscles along its anterior border. In a few instances these muscles may present an unbroken line of origin from the sternal to the acromial end of the bone, but in the vast majority of cases a triangular interval is left between them. This is marked on the surface by a shallow depression, termed the infraclavicular fossa, and it is rendered all the more apparent by the prominence of the shoulder on its outer side, and the sharp backward curvature of the clavicle immediately above it. If the finger be placed in this fossa, and pressed backwards and outwards, it will rest upon the inner side of the coracoid process of the scapula. The articulations of the clavicle should also be examined. Little or no prominence is formed by the outer end of the clavicle—its upper surface passes continuously on to the upper surface of the acromion process of the scapula. By moving the limb, however, the joint can easily be detected. In strong contrast to this is the sterno-clavicular joint, where the inner

end of the clavicle can be felt as a marked projection, although this is masked to the eye by the sternal part of the sterno-mastoid. The suprasternal notch on the upper border of the manubrium sterni between the clavicles should next be felt, and then the finger can be carried downwards in the middle line and in front of the sternum. A prominent ridge, crossing the bone transversely at the level of the second costal cartilages, indicates the junction between the body and manubrium sterni. The portion of the sternum uncovered by the two greater pectoral muscles is very narrow above, but it widens out below, and suddenly, at the lower end of the meso-sternum, the finger sinks into a depression between the cartilages of the seventh pair of ribs, and rests upon the ensiform cartilage. This is termed the infrasternal fossa, or pit of the stomach. The costal arches below the first are easily recognized, but the first rib lies deeply under the clavicle, and can only be felt in front at its junction with the manubrium sterni. The arm should now be abducted (i. e. carried outwards from the trunk), when the hollow of the armpit will be brought into view, as well as the two rounded folds which bound it in front and behind. The anterior fold of the axilla is formed by the lower border of the pectoralis major, and to a small extent also by the lower border of the pectoralis minor. The posterior fold is formed by the latissimus dorsi as it winds round the teres major. Note at this stage that it is carried downwards to a lower level than the anterior fold. This, as we shall see later on, is a most important point in connexion with the anatomy of the axilla. If the finger be pushed upwards into the axilla, the globular head of the humerus can be felt when the arm is rotated. One other point demands the attention of the student before the dissection is commenced, and that is, the position of the nipple. As a rule it lies superficial to the interspace between the fourth and fifth ribs, and it is situated rather more than four inches from the middle line.

Reflection of Skin.—Incisions—(1) Along the middle line of the body from the upper margin of the manubrium sterni to the tip of the ensiform cartilage; (2) from the lower end of this vertical incision transversely outwards round the side of the body; (3) from the upper extremity

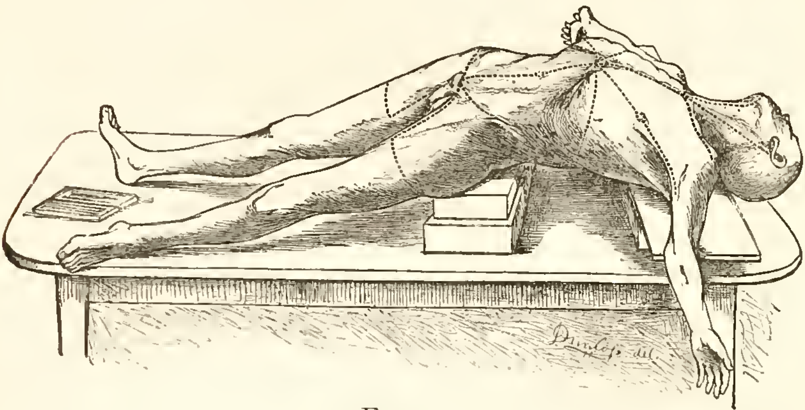

FIG 3.

of the primary incision outwards along the clavicle to the extremity of the acromion process; (4) from the lower end of the vertical and mesial incision (i.e. tip of the ensiform cartilage) obliquely upwards and outwards along the anterior fold of the axilla to the point at which this joins the upper arm. This last incision may, with advantage, be carried vertically down the arm for two and a-half or three inches.

Two triangular flaps of skin are marked out by these incisions, and these are now to be raised from the fatty superficial fascia. It is well to encircle the areola and nipple with the knife, and leave the skin covering them undisturbed.

Superficial Fascia.—The superficial fascia presents here, as elsewhere, the usual characters, but, as a rule, the fat is not so plentiful. As it passes over the clavicle to the upper part of the chest and summit of the shoulder, it will

be seen in most cases to present a faintly ruddy striated appearance. Should this not at first be apparent, the removal of some of the superficial fat will render it visible. This appearance is due to the presence of a number of sparse scattered muscular fibres which stream down over the clavicle, to obtain origin from the deep fascia covering the pectoralis major and deltoid muscles. In the neck they form a thin, cutaneous, fleshy stratum, called *the platysma myoides*. The superficial fascia in this region is also peculiar in so far as it has developed within it the mammary gland. It should now be dissected with the view of exposing the gland as well as the cutaneous vessels and nerves which make it their bed before entering the skin.

Cutaneous Nerves and Arteries.—There are three distinct groups of cutaneous nerves for the supply of the skin on the anterior and lateral aspects of the chest. These are:—

1. The descending cutaneous—from the cervical plexus.
2. The anterior cutaneous, } from the intercostal nerves.
3. The lateral cutaneous, }

The *descending cutaneous nerves* arise in the neck from the third and fourth cervical nerves, and, spreading out as they descend, they cross the clavicle under cover of the platysma myoides. They are classified according to their position into the suprasternal, the supraclavicular, and the supra-acromial branches. The *suprasternal* branch is the smallest of the series, and crosses the inner part of the clavicle to end in the skin immediately below. The *supraclavicular* branches pass over the middle of the clavicle, and extend downwards, for some distance, in the superficial fascia over the pectoralis major. The *supra-acromial* branch crosses the outer third of the clavicle, and will be afterwards followed to the skin of the shoulder.

These nerves can readily be found by cutting down upon the clavicle through the platysma muscle, and in the direction of its fibres.

The *anterior cutaneous nerves* are the minute terminal twigs of the intercostal trunks, and they become superficial by piercing the pectoralis major muscle and deep fascia close to the margin of the sternum. One will be found in each intercostal space, and they are accompanied by the *perforating branches* of the internal mammary artery, which (when injected) serve as the best guides to the nerves. They give slender twigs to the skin over the sternum, and larger branches which are directed outwards, and may be traced as far as the anterior fold of the axilla.

The *lateral cutaneous nerves*, much larger than the preceding, arise from the intercostal nerves, along a line situated a little behind the anterior fold of the axilla. They pierce the chest wall in the interspaces between the ribs, and, under cover of the serratus magnus muscle, they divide into anterior and posterior branches. These will be found appearing between the digitations of the serratus magnus. The *anterior branches* come out, as a rule, about an inch in front of the corresponding posterior branches, and then proceed forwards over the lower border of the pectoralis major muscle. From the lower members of this series some minute twigs are given off, which enter the superficial surface of the digitations of the external oblique muscle of the abdomen. The *posterior branches* run backwards to the dorsal aspect of the trunk over the anterior border of the latissimus dorsi muscle.

Do not attempt to secure the two highest lateral cutaneous nerves (i.e. those issuing from the second and third intercostal spaces) in the meantime. They are best dissected along with the other contents of the axillary space.

Mammary Gland.—Examine next the mammary gland, and make out its precise extent and connections by removing the fatty superficial fascia around it. Carefully reflect the skin, which has been left, towards the summit of the nipple, and, if the subject be a female, insert bristles through the minute external orifices, and try to define the milk ducts with their ampullæ or sacculations. The gland rests on the great pectoral muscle, from which it is separated by the deep fascia and a thin layer of the superficial fascia. In both sexes it is surmounted by a conical elevation, the nipple (*mamilla*), which is surrounded by a pigmented circular area, the *areola*. In adults the position of the nipple can only be accurately observed in the male. It is normally situated over the fourth intercostal space. In the male the nipple is small and the areola surrounded by sparse hairs. In the female the gland extends transversely from the side of the sternum to the axillary border of the pectoralis major, which it occasionally overlaps; and vertically from the third to the sixth or seventh rib. When the adherent fat is carefully removed, the gland is seen to be of a pale reddish colour; convex on its superficial surface, and marked with small depressions occupied by lobules of fat; flattened where it is in contact with the chest; and invested by a firm fibrous capsule which sends trabeculæ into the glandular substance between the lobules, and is attached to the skin by small fibrous bands, the *ligamenta suspensoria* of Sir Astley Cooper. There is no fat in the nipple and areola. In a well-injected subject, twigs from the intercostal and internal mammary arteries will be observed ramifying in the glandular substance, and another branch, the *external mammary* derived from the long thoracic branch of the axillary, may be seen winding round the edge of the pectoralis major, or piercing the lower fibres of that muscle, to enter the gland.

If the subject be a young female the senior student is recommended to conduct the dissection in the following manner:—Remove the gland with the skin and superficial fascia which cover it, and, after dissecting away the fat from its deep surface, introduce a pad of tow underneath

FIG. 4.

Dissection showing the Milk-ducts and their Ampullæ.

the gland, fasten the skin firmly with tacks to a small board, and place the board under water. Then reflect a small portion of skin, as shown in the figure, remove the superficial fat, and proceed to unravel the glandular substance. By this means the milk-ducts can be readily demonstrated. In the Dissecting-room of Trinity College a cork-lined tray is used for this purpose.

The Deep Fascia of the pectoral region is a thin membrane which closely invests the pectoralis major. It is attached superiorly to the clavicle, and is firmly connected in the middle line to the front of the sternum. Below, it is continuous with the deep fascia covering the abdominal muscles. Its strongest fibres are directed outwards,

parallel to the clavicle, and, at the lower border of the great pectoral muscle, it is continuous with the axillary fascia. At the infraclavicular fossa a process from its deep surface dips in to join the costo-coracoid membrane, whilst, beyond this, it becomes continuous with the fascia covering the deltoid muscle. The axillary fascia and the costo-coracoid membrane will be separately described later on.

Pectoralis Major.—This muscle must now be cleaned, and its division into sternal and clavicular parts clearly made out. The muscular fibres are rendered tense by abducting the arm from the side. On the right side the dissector begins at the lower border of the muscle, whilst on the left side he commences at the upper border. Clean also the anterior margin of the deltoid. In the cellular interval between it and the portion of the pectoralis major which arises from the clavicle, the *cephalic vein* and, subjacent to this, the *humeral thoracic* artery will be discovered.

The *pectoralis major* extends from the anterior aspect of the chest to the humerus. It is divided by a deep fissure into a clavicular and a costo-sternal portion. This fissure penetrates through the entire thickness of the muscle, the clavicular and costo-sternal portions being thus separate, except close to their insertion. The *clavicular portion* arises by short tendinous and muscular fibres from an impression on the inner half of the anterior surface of the clavicle. The *costo-sternal portion* takes origin by fleshy fibres from the anterior surface of the sternum, from the aponeurosis of the external oblique muscle, and occasionally from the sixth rib near its cartilage. Under cover of this more superficial origin, and partially independent of it, a variable number of muscular slips spring from the cartilages of the upper six ribs.

The pectoralis major is inserted by a flattened bilaminar tendon into the outer lip of the bicipital groove of the

humerus (pectoral ridge), and the fibres of the muscle undergo a re-arrangement as they converge upon this tendon. The greater part of the clavicular portion joins the anterior lamina of the common tendon; some of the innermost clavicular fibres, however, are inserted directly into the humerus below the tendon, whilst a few gain attachment to the deep fascia of the arm, and become adherent to the adjacent part of the deltoid.

The fibres of the costo-sternal portion of the muscle take different directions as they proceed to join both laminæ of the tendon of insertion; thus the upper fibres descend slightly, the intermediate fibres pass horizontally outwards, whilst the lower fibres ascend, and, at the same time, gain the deep surface of the rest of the muscle. A smooth, full, and rounded lower border is in this way formed which constitutes the anterior fold of the axilla. The bilaminar tendon of the pectoralis major is the direct continuation of the axillary fold, and its two laminæ are thus united, or, in other words, continuous below. The precise manner in which it is attached will be more fully studied at a later stage of the dissection (p. 57).

AXILLA OR ARMPIT.

The axilla may be defined as being the hollow or recess between the upper part of the side of the chest and the upper part of the arm. When the limb is abducted from the trunk, and the areolo-fatty tissue which occupies it removed, it presents a distinctly pyramidal form. The apex, or narrow part of the space, placed immediately to the inner side of the coracoid process, is directed upwards towards the root of the neck, whilst the wider part or base looks downwards. But the space is not absolutely pyramidal in form, for the inner wall formed by the chest is of greater extent than the outer wall formed by the arm. It follows from this, therefore, that the anterior and posterior walls converge as they proceed outwards.

Before engaging in the dissection of the space, it is necessary that the student should have some knowledge of its boundaries, and the manner in which its contents are disposed in relation to these.

Boundaries of the Axilla.—The *anterior* wall is formed by the two pectoral muscles and the costo-coracoid membrane. The pectoralis major constitutes the superficial stratum, and is spread out over the entire extent of the anterior wall. The pectoralis minor, which lies subjacent to the greater pectoral muscle, is only in relation to about one-third of the anterior boundary, whilst the interval or gap between this muscle and the clavicle is filled up by the costo-coracoid membrane. The lower border of this wall of the axilla constitutes its *anterior fold*, as already explained. This is formed by the lower margin of the

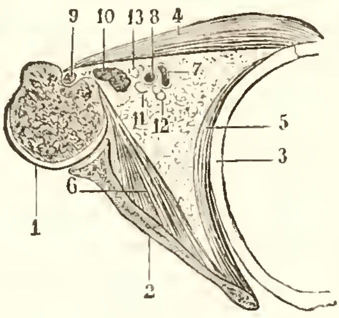

FIG. 5.

Diagram of Section through the Axilla of the Left side.

1. Upper end of humerus.
2. Scapula.
3. Rib.
4. Pectoralis major.
5. Serratus magnus.
6. Subscapularis.
7. Axillary vein.
8. Axillary artery.
9. Long head of biceps.
10. Conjoined origin of short head of biceps and coraco-brachialis.

11, 12, 13. Brachial nerves.

pectoralis major, with a small part of the lower border of the pectoralis minor, which comes into view near the side of the chest.

The *posterior wall* of the axilla is somewhat longer than the anterior wall. It is formed from above downwards by the subscapularis muscle, the tendon of the latissimus dorsi, and the teres major muscle. The subscapularis, lying upon the venter of the scapula, takes by far the largest share in the formation of this boundary. The narrow tendon of the latissimus dorsi lies in front of the teres major, so that only a very small part of the latter muscle is seen below it. The *posterior fold* of the axilla is formed by the lower border of this wall.

The *inner wall* is constituted by the upper four or five ribs with the intervening intercostal muscles; it is clothed by the corresponding digitations of the serratus magnus.

The *outer wall* is formed by the humerus and the conjoined origin of the coraco-brachialis and short head of the biceps.

The *apex* of the space corresponds with the narrow communication between the axilla and the root of the neck. It is a triangular interval (which can readily be investigated by the finger when the space is dissected) bounded by the clavicle, first rib, and upper margin of the scapula, and through it pass from the neck the great axillary vessels and brachial nerves. The wide vaulted *base* of the armpit is closed by the axillary fascia.

Contents.—The axillary artery and vein, with the great brachial nerves, constitute the most important contents of the armpit. Except at the summit of the space, they lie closely applied to the outer wall, and follow it in all the movements of the upper arm. Of the branches which spring from the axillary artery, *two* (viz. the thoracic axis and the long thoracic) are related to the anterior wall; *two* (viz. the posterior circumflex and subscapular) to the posterior wall; *one*, the superior thoracic, to the inner wall; and *one*, the anterior circumflex, to the outer wall.

The *thoracic axis* arises high up in the space, and at

once proceeds forwards through the costo-coracoid membrane. The *long thoracic* artery runs inwards along the lower border of the pectoralis minor. The *posterior circumflex* artery arises from the posterior aspect of the main trunk, and at once leaves the space by passing backwards through the posterior wall in the interval between the subscapularis and the teres major. The *subscapular artery* runs inwards along the lower border of the subscapularis muscle. The *anterior circumflex*, a small vessel, proceeds outwards upon the humerus, under cover of the coraco-brachialis and short head of the biceps. The *superior thoracic*, also a small vessel, ramifies upon the first intercostal space high up in the axilla.

In making an opening into the axilla from below, for the purpose of allowing a collection of pus to escape, or for any other purpose, it is manifestly absolutely necessary to bear these relations in mind. The outer wall, where the great axillary vessels are, must be most carefully avoided; so also must be the anterior and posterior walls, where there would be a risk of injuring the long thoracic and subscapular arteries. The inner wall, however, is, comparatively speaking, free from danger, as the small thoracica suprema is placed high up in the space. Therefore enter the knife with the sides of the blade towards the anterior and posterior walls of the space, and with the back of the blade towards the outer wall and axillary vessels. The knife may then be carried inwards towards the chest.

But there are various nerves in relation to the walls of the axilla. Entering the deep surface of the anterior wall are the *two anterior thoracic nerves* for the supply of the pectoral muscles. Upon the posterior wall are the *three subscapular nerves*, which supply the three muscles which constitute this boundary. Running downwards upon the inner wall is the *nerve of Bell*, while piercing it are the *intercosto-humeral* and upper *lateral cutaneous nerves*.

In addition to the contents already enumerated, numerous lymphatic glands are lodged in the fat of the axillary space.

Before proceeding with the dissection the student will do well to refer to Fig. 6. It represents a horizontal section through the right

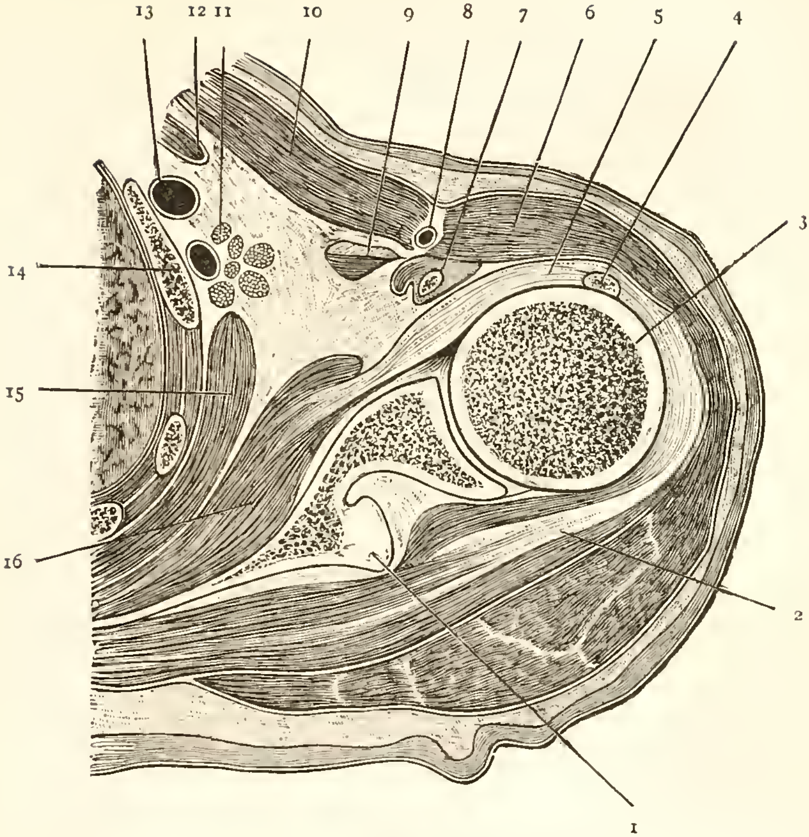

FIG. 6.

Transverse Section through the Right Shoulder, and Apex of the Axilla.

1. Spine of the scapula.
2. Infraspinatus.
3. Head of humerus.
4. Long head of the biceps.
5. Capsule of the shoulder-joint.
6. Deltoid.
7. Tip of coracoid process, surrounded by the conjoined origin of the coraco-brachialis and short head of the biceps.
8. Cephalic vein.
9. Pectoralis minor.
10. Pectoralis major.
11. Subclavian artery and brachial nerves.
12. Subclavius.
13. Subclavian vein.
14. First rib.
15. Serratus magnus.
16. Subscapularis.

Note the connection between the capsule of the shoulder-joint and the tendons of the subscapularis and infraspinatus. The opposing rotatory action which these muscles exercise upon the humerus can be easily understood by an examination of this section.

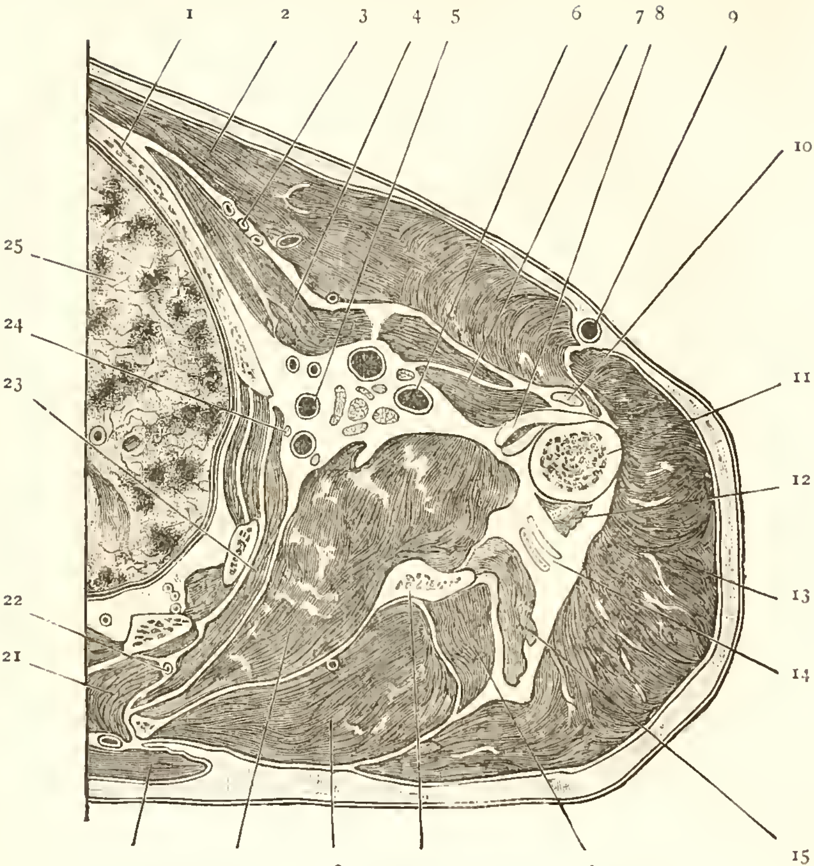

FIG. 7.

Transverse Section through the Right Axilla.

1. Third rib.
2. Pectoralis major.
3. Pectoral thoracic arteries.
4. Pectoralis minor.
5. Subscapular artery.
6. Axillary artery.
7. Coraco-brachialis; short head of biceps immediately in front of this.
8. Tendons of latissimus dorsi and teres major.
9. Cephalic vein.
10. Long head of biceps.
11. Humerus.
12. Outer head of triceps.
13. Deltoid.
14. Posterior circumflex artery and circumflex nerve.
15. Long or scapular head of triceps.
16. Teres minor.
17. Axillary border of scapula.
18. Infraspinatus.
19. Subscapularis.
20. Trapezius.
21. Rhomboideus major.
22. Posterior scapular artery.
23. Serratus magnus.
24. Nerve of Bell.
25. Right lung.

shoulder and axillary region, near the apex of the latter. The axilla appears as a triangular space, occupied for the most part by fat, but showing on its inner side the brachial plexus of nerves, the subclavian artery, close to the point at which it becomes the axillary artery, and the corresponding part of the subclavian vein. These structures are all cut transversely, as the section was made with the arm close to and parallel with the body. Had the limb been extended at right angles to the trunk previous to freezing, they would have been cut nearly longitudinally. On the *inner* wall the first, second, and third ribs are seen in section with the intercostal muscles and serratus magnus; on the *outer* wall the coraco-brachialis and biceps muscles appear. *Anteriorly* the pectoralis major, the pectoralis minor and subclavius close in the space; *posteriorly* the subscapularis is seen. The student should bear in mind that it is only in frozen sections that the *exact relations of the parts can be accurately studied.* Much can be learned from a properly dissected axilla; but the large open space which is thus displayed differs widely from the small, triangular, intermuscular recess which is seen in a frozen section.

Figure 7 gives a view of a section through the axillary space at a lower level, and with the arm still by the side. The triangular outline of the space is seen; the boundaries and contents are also apparent. The great vessels and nerves will be observed to have shifted more to the outer side of the recess. Note further the tendons of insertion of the latissimus dorsi and teres major, which are cut in front of the shaft of the humerus.

The Axillary Fascia is a dense felted membrane which stretches across the base of the armpit. It is continuous in front with the deep fascia covering the pectoralis major, behind with the sheaths of the latissimus dorsi and teres major muscles, and internally with the deep fascia over the serratus magnus. Notice that it is drawn upwards towards the hollow of the axilla. This is chiefly due to the connection of its deep surface with the sheath of the pectoralis minor, but also to its attachment to the areolar tissue which fills the space. In a well-injected subject a small artery, from the lower part of the axillary trunk, may be observed ramifying upon the fascia.

Dissection of the Axilla from below.—Begin the dissection of the axilla by carefully separating the deep fascia

from the lower edge of the pectoralis major muscle, so as to expose and clean the anterior fold of the axilla. Then grasp the edge of the fascia with the hand and pull it backwards, teasing out with the point of the knife the areolar tissue, which holds it in place. By this means the axillary fascia is reflected in one piece, and the upper lateral cutaneous nerves are put on the stretch, and can be followed out.

Lateral Cutaneous Branches of the Second and Third Intercostal Nerves.—As a rule, the first intercostal nerve does not give off a lateral cutaneous nerve. That which springs from the second intercostal nerve is the largest of the series, and differs from the others in not dividing into an anterior and posterior branch. It is termed the *intercosto-humeral nerve*, on account of its being distributed to the skin on the inner and back aspect of the upper part of the arm. To reach this destination it crosses the axilla and pierces the deep fascia. But before doing so it establishes communications and forms a plexiform arrangement in the axilla with the nerve of Wrisberg (the lesser internal cutaneous nerve) and the lateral cutaneous branch of the third intercostal nerve.*

The *lateral cutaneous branch* of the third intercostal nerve divides into an anterior and posterior part, and these are distributed in the ordinary way. From the posterior branch twigs are given to the skin of the axilla, and the terminal twigs are distributed to the integument on the upper part of the inner aspect of the arm.

Lymphatic Glands.—In the subsequent dissection of the axilla the lymphatic glands must be removed as they

* This plexus may be joined by another twig, which is occasionally present, viz. the minute lateral cutaneous branch of the first intercostal nerve.

are brought into view. The position which they occupy in the space should, however, in the first place, be carefully noted. They are disposed in three groups—(*a*) a group lying close to the axillary vessels which receives the lymphatic vessels ascending from the limb; (*b*) a group of pectoral glands placed along the lower border of the pectoralis minor, which are joined by the lymphatics from the mammary gland and front of the chest; (*c*) a group of subscapular glands, situated along the lower border of the subscapularis muscle on the posterior wall of the axilla, and into which the lymphatics of the back pour their contents.

Dissection.—The loose areolar tissue and fat must now be cautiously removed from the hollow of the armpit. Begin by dissecting out the *subscapular artery* and the *long subscapular nerve*. The guide to their position is the lower margin of the subscapularis muscle. In relation to the lower border of the pectoralis minor muscle the *long thoracic artery* will be found. A vertical incision along the inner wall, a short distance anterior to the point where this joins the posterior wall, will display the *external respiratory nerve*, or the *nerve of Bell*, upon the axillary surface of the serratus magnus. These structures being secured, the dissector may proceed with his work more boldly, as the remaining contents of the space are not so liable to injury. The *axillary artery and vein* and the great *brachial nerves* may next be exposed. Note the close manner in which they cling to the outer wall of the axilla in the various movements of the limb, and then isolate them thoroughly by removing their areolar sheaths, and establish their individual identity. In dissecting these structures care must be taken to secure the small *internal cutaneous* branch of the *musculo-spiral nerve*. This nerve is generally given off within the axilla in common with a muscular branch to the long head of the triceps, and it crosses the latissimus dorsi and teres major tendons on a

deeper plane than the branches of the intercosto-humeral nerve.

It is the third part of the axillary artery which is now exposed, and the vein will be seen to lie upon its inner side, but also partly in front of it. It is important to note the position of the large nerves, with reference to the artery, before they are much disturbed by the dissection. The *ulnar nerve* lies in direct contact with its inner side. The *nerve of Wrisberg* (*the lesser internal cutaneous nerve*) is also internal to the artery, but is separated from it by the axillary vein, to which it is closely applied. The *internal cutaneous nerve*, and the *inner head of the median*, lie in front of the artery; the *musculo-spiral* and *circumflex nerves* are directly behind it; while the *median* and *musculo-cutaneous nerves* are placed upon its outer side. The latter nerve soon leaves the artery, by deviating outwards and entering the substance of the coraco-brachialis muscle. Its branch of supply to that muscle should be secured at this stage.

In this part of its course the axillary artery gives off three branches—the *subscapular*, which has already been found; the *posterior circumflex*, which arises from its posterior aspect; and the *anterior circumflex*, a small vessel which runs outwards under cover of the coraco-brachialis, and is apt to be injured in cleaning the nerves. The *lower subscapular nerve* must now be looked for upon the surface of the subscapularis muscle.

Dissection of Axilla from the front.—The axillary space must now be dissected from the front. This is done by reflecting the clavicular part of the pectoralis major. The sternal portion of the muscle is not to be disturbed at present. Divide the clavicular part close to its origin from the clavicle, and throw it downwards and outwards. This must be done with care, because some twigs from the *external anterior thoracic* nerve, and also some of the *pectoral thoracic* branches of the thoracic axis artery, enter

its deep surface. These must be thoroughly cleaned and preserved.

Costo-Coracoid Membrane.—A space or gap bounded by the clavicle, pectoralis minor, sternal part of the pectoralis major, and coracoid process, is now exposed. This gap, however, is closed by the costo-coracoid membrane, the connexions of which must be studied. Trace it outwards to its attachment to the coracoid process, and inwards to its attachment to the first rib. Above it con-

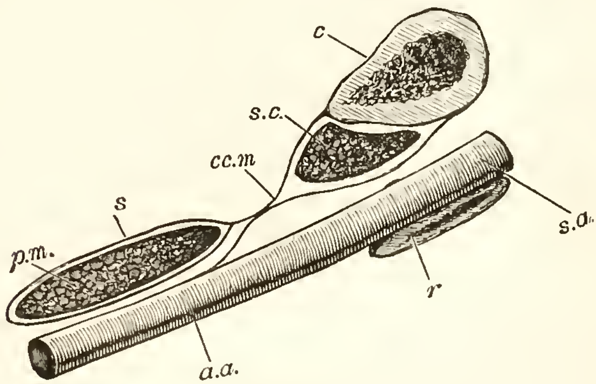

FIG. 8.

Diagram to show the Upper and Lower Attachments of the Costo-coracoid Membrane.

c.	Clavicle.	*s.c.*	Subclavius muscle.
r.	First rib.	*cc.m.*	Costo-coracoid membrane.
s.a.	Subclavian artery.	*s.*	Sheath of pectoralis minor.
a.a.	Axillary artery.	*p.m.*	Pectoralis minor muscle.

stitutes the sheath of the subclavius muscle by splitting into an anterior and a posterior layer. These, passing upwards, enclose the muscle, and are attached, the one to the anterior border of the clavicle, and the other to the posterior border of the bone. But how can the two layers be demonstrated? Divide the anterior lamina transversely close to the clavicle, and throwing it down-

wards, pass the handle of the scalpel upwards behind the muscle. The posterior attachment can in this manner be verified, and at the same time the nerve to the subclavius will be seen sinking into the deep surface of the muscle. Observe that the density of the membrane diminishes almost immediately below the subclavius, and this so abruptly that a crescentic margin is formed, which, on account of its being thicker and stronger than the rest of the membrane, is sometimes called the costo-coracoid, or bicornuate ligament. The lower connexions of the membrane are somewhat indefinite, and difficult to establish with precision. In a good subject, however, it will be seen to join the sheath of the axillary vessels, and also to give a process of fascia to the sheath of the pectoralis minor.

Four structures pierce the costo-coracoid membrane, and these should now be cleaned. They are:—(1) the
Tho. thoracic axis artery, breaking up into pectoral, clavicular,
acromial, and humeral branches; (2) the thoracic axis acrom. Tho.
vein; (3) the cephalic vein; (4) and lastly, the external anterior thoracic nerve.

The costo-coracoid membrane should be removed, and the axillary space entered from above. With a little dissection the contents of the upper part of the space may be exposed. The *axillary artery* is the most important object. It is wrapped round by a loose funnel-shaped sheath, which is prolonged into the axilla from the deep cervical fascia. This must be cleared away. The *axillary vein* lies on the inner side and partly in front of the artery, whilst above and external to it the three large brachial nerve-trunks are placed. Crossing behind the artery, and therefore lying very deeply, is the *external respiratory nerve*, or *nerve of Bell*. A small branch, called the *superior thoracic*, takes origin from this part of the axillary artery, and must be followed out. Lastly, the *cephalic and thoracic axis veins* must be traced to their junction with the axillary vein.

Pectoralis Minor Muscle.—Divide the sternal part of the pectoralis major muscle about its middle, and throw the two portions outwards and inwards. Several nerves will be observed entering its deep surface, and these must be preserved. They come from the external and internal anterior thoracic nerves. One or more from the latter pierce the pectoralis minor, and are now seen emerging from its anterior surface. The pectoralis minor must be cleaned and its attachments defined.

The *pectoralis minor* is a fan-shaped muscle, which extends from the thoracic wall to the scapula. It arises by three flat, tendinous slips from the third, fourth, and fifth ribs, close to their cartilages. Between the ribs these slips are prolonged into the anterior intercostal aponeuroses. From this origin the fibres proceed outwards and upwards, and converge upon a stout tendon, which is inserted into the front part of the inner border and upper surface of the coracoid process. The pectoralis minor is supplied by the internal anterior thoracic nerve.

Axillary Artery.—The axillary vessels and the brachial nerves can now be cleaned throughout their entire extent, but the pectoralis minor muscle should not be reflected until the relations of these important structures have been thoroughly studied.

The *axillary artery* is a portion of the great arterial trunk which carries blood for the supply of the upper limb. It begins above at the outer border of the first rib, where it is continuous with the subclavian artery, and it ends below at the lower border of the teres major muscle, where it becomes continuous with the brachial artery. Its course through the axilla varies with the position of the limb. When the arm is abducted from the trunk (as it is when the axilla is being dissected), the student should observe that a straight line—drawn from the centre of the clavicle to a point below the anterior fold of the axilla, and immediately to the inner side of the slight prominence

caused by the coraco-brachialis muscle—will, with tolerable accuracy, indicate the course pursued by the vessel.

The relations of the axillary artery vary very much as it traverses the armpit; and with the view of obtaining a greater precision of description, anatomists are in the habit of arbitrarily dividing the vessel into three parts, according to the position which it occupies with reference to the pectoralis minor muscle. The *first* part extends from the outer border of the first rib to the upper border of the pectoralis minor; the *second* part lies under cover of that muscle; the *third* part extends from the lower border of the pectoralis minor to the lower border of the teres major.

The *first part* of the axillary artery lies very deeply. It is covered by the skin, superficial fascia, deep fascia, clavicular part of the pectoralis major, and the costo-coracoid membrane. But, even when these are removed, the vessel is not completely exposed, because it is enveloped, along with the vein and great nerves, by a funnel-shaped sheath, which is prolonged upon it from the deep cervical fascia, and it is crossed by the *cephalic and thoracic axis veins.* The loop of communication between the two anterior thoracic nerves likewise lies in front of it. *Posteriorly* this part of the vessel is supported by the first intercostal space and the first digitation of the serratus magnus muscle, and the nerve of Bell crosses behind it. To its *inner side*, and somewhat overlapping it, is the axillary vein, whilst *above* and to its *outer side* are the three large brachial nerve-trunks.

The *second part* of the axillary artery is placed behind the two pectoral muscles, and has the three cords of the brachial plexus disposed around it. Thus the inner cord lies upon its inner side, the outer cord upon its outer side, and the posterior cord behind it. The axillary vein is still upon its inner side, but is separated from the artery by the inner nerve-cord. Strictly speaking, it is not in apposition with any muscle posteriorly, being separated

from the subscapularis muscle by a quantity of areolo-fatty tissue.

The *third and longest part* of the axillary artery is superficial in its lower half. This is due to the fact that the posterior wall of the axilla extends lower down than the anterior wall. Whilst, therefore, it is covered in its upper half by the pectoralis major, below this it is only covered by the integument and fasciæ. *Behind* it rests, from above downwards, on the subscapularis, the tendon of the latissimus dorsi, and the lower margin of the teres major. To its *outer side* is the coraco-brachialis; whilst to its *inner side* is the axillary vein. The brachial nerve-cords have now given place to their large branches, and these are disposed around the vessel. The precise positions which they occupy in the undisturbed condition of parts has been already described in page 34.

The *branches* of the axillary artery have been observed at different stages of the dissection. They may now be more fully examined. They are :—

Superior thoracic, . .	from the first part.
Thoracic axis, . .	from the second part.
Long thoracic, . .	
Alar thoracic, . .	from the third part.
Subscapular, . . .	
Anterior circumflex, .	
Posterior circumflex, .	

The Superior Thoracic Artery is a small branch which springs from the axillary at the lower border of the subclavius muscle and ramifies upon the upper part of the inner wall of the axilla. It supplies twigs to the serratus magnus muscle, the intercostal muscles, and the pectoral muscles.

The Thoracic Axis or Acromio-thoracic Artery is a short wide trunk, which is usually described as arising from the first part of the axillary artery. As a rule, however, it

takes origin under cover of the pectoralis minor, and winds round the upper border of that muscle. Piercing the costo-coracoid membrane, it immediately divides into numerous branches, which diverge widely from each other. These receive different names, and are arranged as follows:—(*a*) *The clavicular branch*, a very minute twig, runs upwards to the subclavius muscle. (*b*) *The pectoral branches*, of larger size, proceed downwards between the two pectoral muscles, give branches to both, and anastomose with the long thoracic and intercostal arteries. (*c*) *The acromial branch* runs outwards upon the tendon of the pectoralis minor and the coracoid process. Some of its twigs supply the deltoid, whilst others pierce it to reach the upper surface of the acromion process. It anastomoses with the suprascapular and posterior circumflex arteries. (*d*) *The humeral branch*, as a rule, takes origin from a trunk common to it and the preceding artery, and it runs downwards in the intermuscular interval between the pectoralis major and the deltoid. To both of these muscles it gives twigs.

The Long Thoracic Artery takes the lower border of the pectoralis minor as its guide, and proceeds downwards and inwards to the side of the chest. It gives branches to the pectoral muscles, the serratus magnus, and the mammary gland, and anastomoses with twigs from the intercostal arteries. It gives off, as a rule, an *external mammary* branch, which winds round or pierces the lower border of the pectoralis major to reach the mammary gland.*

The Alar Thoracic supplies the fat and lymphatic glands in the axilla, and rarely arises as a separate branch from the axillary artery. Its place is usually taken by twigs from the subscapular and long thoracic arteries.

* This branch may arise separately from the axillary artery. Some authors apply the term *external mammary* to the long thoracic artery.

Subscapular Artery.—This is the largest branch of the axillary artery, and it arises opposite the lower border of the subscapularis muscle. Following this, it runs downwards and backwards, in company with the long subscapular nerve, to the inferior angle of the scapula, where its terminal twigs anastomose with the posterior scapular artery. Not far from its origin the subscapular artery gives off a large branch, the *dorsalis scapulæ* which winds round the axillary border of the scapula, in close contact with the bone, to reach its dorsal aspect. Numerous smaller twigs are given to the neighbouring muscles, viz. the subscapularis, latissimus dorsi, and serratus magnus.

Circumflex Arteries.—These are two in number, and as a rule they both arise from the axillary at the same level, a short distance below the origin of the subscapular artery. The *posterior circumflex* is much the larger of the two. Only a small portion of it can be seen at the present stage. It springs from the posterior aspect of the axillary, and at once proceeds backwards with the circumflex nerve close to the inner and under aspect of the head of the humerus, and in the interval between the subscapularis and teres major muscles. The small *anterior circumflex artery* takes origin from the outer aspect of the axillary, and runs outwards in front of the surgical neck of the humerus, under cover of the coraco-brachialis and short head of the biceps. Reaching the bicipital groove it divides into two branches. Of these one is directed upwards with the long head of the biceps to the shoulder-joint; the other continues onwards to the under surface of the deltoid, and finally anastomoses with some of the terminal twigs of the posterior circumflex artery.

Axillary Vein.—This venous trunk is the continuation upwards of the basilic vein of the upper arm. Beginning at the lower border of the teres major, it becomes the subclavian vein at the outer margin of the first rib. At

the lower margin of the subscapularis it receives the two *venae comites* of the brachial artery, and above the level of the pectoralis minor it is joined by the cephalic vein. Its other tributaries correspond to the branches of the axillary artery.

The Subclavius Muscle may now be cleaned and its attachments defined. It is a small muscle, placed below the clavicle, and it is enclosed in a stout sheath derived from the costo-coracoid membrane. It takes origin by a short rounded tendon, from the upper surface of the first costal arch at the junction of the rib with its cartilage, and the small fleshy belly is inserted into the shallow groove on the under surface of the clavicle. Its nerve of supply comes from the fifth and sixth cervical nerves and has been previously noticed, p. 36.

Dissection.—The middle third of the clavicle should now be removed, and the subclavius muscle reflected, in order that a connected view of the structures which pass from the side of the neck into the axilla may be obtained. The dissector of the head and neck should also take part in this dissection. At the same time the pectoralis minor may be divided about an inch and a-half from its insertion, and the two parts thrown inwards and outwards. In doing this care must be taken of the internal anterior thoracic nerve which pierces its deep surface. When the continuity of the axillary and subclavian vessels has been satisfactorily displayed they may be ligatured in two places at the level of the clavicle and then divided between the ligatures. By throwing the axillary vessels downwards the examination of the brachial nerves will be greatly facilitated The dense connective tissue which surrounds these large nerves should be completely removed and the arrangement of the brachial plexus studied.

The Brachial Plexus is formed by the anterior primary divisions of the four lower cervical nerves and the greater

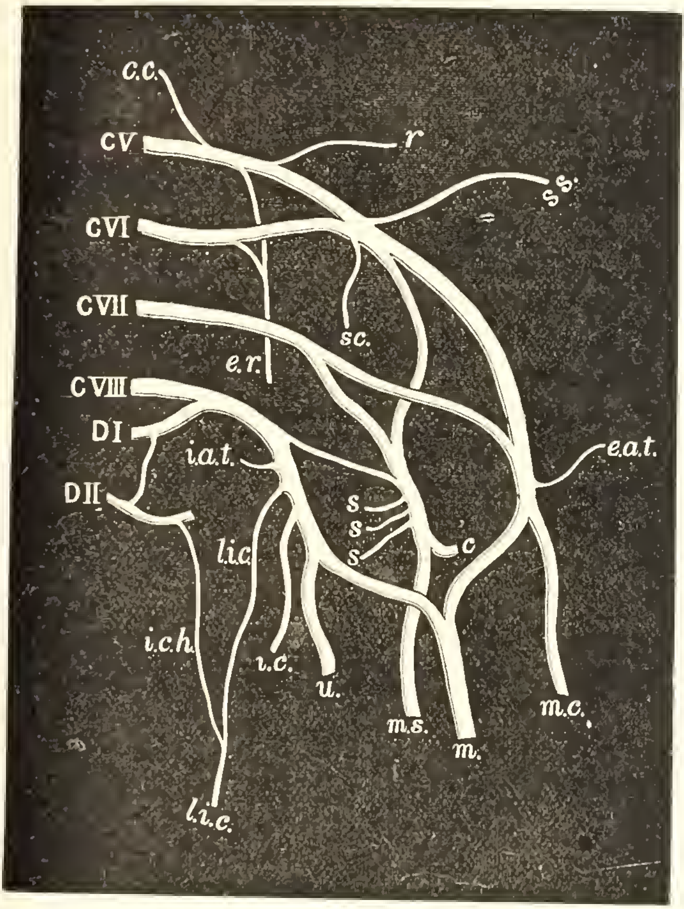

FIG. 9.

Diagram of the Brachial Plexus.

CV, CVI, CVII, CVIII, The four anterior primary divisions of the cervical spinal nerves which take part in its formation. D I and D II, The anterior primary divisions of the first two dorsal nerves. *c.c.*, Communicating twig from the fourth cervical nerve. *r.*, Nerve to rhomboids. *s.s.*, Suprascapular nerve. *s.c.*, Nerve to subclavius. *e.r.*, External respiratory nerve, or nerve of Bell. *c.a.t.*, External anterior thoracic nerve. *m.c.*, Musculo-cutaneous nerve. *m.*, Median nerve. *i.a.t.*, Internal anterior thoracic nerve. *l.i.c.*, Lesser internal cutaneous nerve, or the nerve of Wrisberg. *i.c.h.*, Intercosto-humeral nerve. *i.c.*, Internal cutaneous nerve. *u.*, Ulnar nerve. *s, s, s*, The three subscapular nerves. *c.*, Circumflex nerve. *m.s.*, Musculo-spiral nerve.

part of the large anterior primary division of the first dorsal nerve. Above, the plexus is further reinforced by

a small twig of communication which passes from the fourth to the fifth cervical nerve, whilst below, a similar connecting twig not infrequently passes upwards, in front of the neck of the second rib, from the second to the first dorsal nerve. The manner in which these great nerves unite to form the plexus is very constant. The *fifth* and *sixth* nerves unite to form an *upper* trunk; the *seventh* remains single and proceeds downwards as a *middle* trunk; whilst the *eighth cervical* and *first dorsal* nerves join close to the intervertebral foramina to constitute a *third* or *lower* trunk. In the form of these three trunks, the brachial plexus passes behind the clavicle and enters the axilla. Here each trunk splits into an *anterior* and a *posterior division*. Raise the three anterior divisions on the handle of the knife, and then it will be seen that all the three posterior divisions unite to form the *posterior cord* of the plexus, and, further, that the innermost of these divisions is much smaller than the other two. Of the three anterior divisions the *two outer* join to constitute the *outer cord*, whilst the *innermost* is carried downwards by itself as the *inner cord* of the plexus. From the three cords of the plexus are given off the branches which supply the upper limb.

From the above description it will be seen that the plexus, from changes which are effected in the arrangement of its fibres, may be divided into four stages:—

First stage, . .	Five separate nerves (viz. four lower cervical and first dorsal).
Second stage, . .	Three nerve-trunks (viz. an upper, middle, and lower).
Third stage, . .	Three anterior divisions and three posterior divisions.
Fourth stage, . .	Three nerve-cords (viz. an outer, inner, and a posterior).

The two first of these stages are generally observed in the lower part of the posterior triangle of the neck, and

the two last behind the clavicle and in the upper part of the axilla. It must be understood, however, that the points at which division and union of the different parts of the plexus take place are subject to variation.

Infraclavicular Branches of the Brachial Plexus.—The branches of the brachial plexus are usually classified into two groups, viz. those which arise above the level of the clavicle, and those which take origin within the axilla. The latter group of nerves must now be studied by the dissector of the upper limb. They consist of a number of short branches, which end in the muscles forming the anterior and posterior walls of the axilla, and a series of large terminal branches, which are prolonged downwards into the upper arm. They are :—

1. *Axillary branches*—

    From outer cord :

    External anterior thoracic.

    From inner cord :

    Internal anterior thoracic.

    From posterior cord :

    Three subscapular nerves.

2. *Brachial branches*—

    From outer cord :

    Musculo-cutaneous.
    Outer head of median.

    From inner cord :

    Inner head of median.
    Ulnar.
    Internal cutaneous.
    Lesser internal cutaneous.

    From posterior cord :

    Circumflex.
    Musculo-spiral.

The Anterior Thoracic Nerves are the branches of supply to the pectoral muscles, or, in other words, to the

two muscles which form the anterior wall of the axilla. The *external anterior thoracic* nerve springs from the outer cord of the plexus, pierces the costo-coracoid membrane above the level of the pectoralis minor, and breaks up into branches which sink into the deep surface of the pectoralis major. The *internal anterior thoracic* nerve, somewhat smaller, arises from the inner cord of the plexus, and passing forwards between the axillary artery and vein enters the deep surface of the pectoralis minor. After supplying this muscle its terminal filaments emerge from its anterior surface, and sink into the pectoralis major. The pectoralis major is therefore supplied by both anterior thoracic nerves; the pectoralis minor by the internal anterior thoracic nerve alone. Close to their origin the two nerves are usually united by an arch or loop, thrown over the front of the axillary artery; in other cases they may join in a plexiform manner, before proceeding to their destinations.

Subscapular Nerves.—The three subscapular nerves spring from the posterior cord of the plexus, and supply the three muscles which form the posterior wall of the axilla. The *upper subscapular nerve* is placed high up in the axilla. It is very short, sometimes double, and it sinks into the substance of the subscapularis muscle. The *long* or *middle subscapular nerve* accompanies the subscapular artery and supplies the latissimus dorsi. The *lower subscapular nerve* gives twigs to the lower border of the subscapularis muscle, and ends in the teres major.

Dissection.—The cords of the brachial plexus may now be divided. Begin with the inner and outer cords, because when these are thrown downwards a better view of the posterior cord and the three subscapular nerves will be obtained. When the posterior cord is cut the arm should be forcibly dragged away from the trunk, so as to put the serratus magnus on the stretch.

Posterior Thoracic Nerve and Serratus Magnus Muscle.—The *external respiratory nerve of Bell*, or the posterior thoracic nerve, as it passes downwards upon the outer surface of the serratus magnus, may now be studied in its whole length. It is the nerve of supply to the serratus magnus, and it arises in the root of the neck by three roots from the brachial plexus. The upper two roots (one from the fifth cervical and the other from the sixth cervical nerve) pierce the scalenus medius, and uniting into one stem give off branches to the upper part of the serratus magnus. The third root takes origin from the seventh cervical nerve, and passes in front of the scalenus medius. It runs downwards for a considerable distance on the surface of the serratus magnus, before it unites with the other part of the nerve. The entire nerve, thus formed, can be followed to the lower part of the serratus, giving twigs to each of its digitations. The upper part of the nerve is very deeply placed, and passes behind the axillary vessels; the lower part on the side of the chest is comparatively superficial, being covered by only skin and fascia.

The *serratus magnus* arises by fleshy digitations from the upper eight or nine ribs, about midway between their angles and cartilages. These slips are arranged on the chest-wall, so as to present a gentle curve convex forwards. The lower three or four interdigitate with the external oblique muscle of the abdomen. The serratus magnus is inserted into the entire length of the vertebral border of the scapula. The muscle falls naturally into three parts. (*a*) The *upper part*, composed of the large first digitation alone, arises from the first and second ribs, and from a tendinous arch between them. The fibres converge, to be inserted into a somewhat triangular surface in front of the superior angle of the scapula. (*b*) The *middle part* consists of two digitations which take origin from the second and third ribs. The upper slip is very broad, and springs from the lower border of the second rib. The fibres diverge to

form a thin muscular sheet, which is inserted into the anterior lip of the vertebral border of the scapula, between the insertions of the upper and lower portions. Sometimes this part of the muscle is not directly attached to the bone, but to a strengthened band of the fascia covering the subscapularis. (*c*) The *lower part* is formed by the remaining digitations of the muscle. These converge to form a thick mass, which is inserted into a rough surface upon the deep aspect of the inferior angle of the scapula. The deep surface of the serratus magnus is in contact with the chest wall. Its superficial surface is separated *above* from the subscapularis, the axillary vessels, and the brachial plexus of nerves, by a mass of adipose and areolar tissue; *below*, it is subcutaneous.

Removal of the Arm from the Body.—Draw the arm forcibly from the side and cut through the serratus magnus, the levator anguli scapulæ, the omo-hyoid, and the latissimus dorsi muscles, also the suprascapular artery and nerve, and the vessels and nerves in relation to the trapezius and rhomboids, if these have not been previously divided. The arm will then be found to be free, and it may be carried to one of the tables which are reserved for the dissection of separate parts.

SHOULDER—SCAPULAR REGION.

In the dissection of this region the following parts must be studied :—

1. Cutaneous nerves of the shoulder.
2. Deep fascia.
3. Deltoid muscle.
4. Sub-acromial bursa.
5. Anterior and posterior circumflex vessels.
6. Circumflex nerve.
7. Dorsalis scapulæ artery.
8. Subscapularis muscle.
9. Supraspinatus, infraspinatus, teres minor, and teres major muscles.
10. Bursæ in connection with the shoulder-joint.
11. Suprascapular nerve and artery.
12. Acromio-clavicular joint, and the coraco-acromial arch.

The insertions of the muscles which have already been divided should first engage the attention of the student. These should be carefully defined and the precise extent of each studied. Begin with the omo-hyoid, which springs from the superior border of the scapula ; then deal in the same way with the levator anguli scapulæ, rhomboideus minor and major, which are attached to the vertebral border of the bone, and the serratus magnus, which is inserted into the ventral aspect of the superior and inferior angles, and the intervening portion of the vertebral border of the scapula. The insertion of the pectoralis minor into the coracoid process, and of the trapezius into both clavicle and scapula should also be thoroughly examined. When this has been done these divided muscles may be removed, with the exception of about half an inch of each, which it is advisable to leave attached to the bones for future reference.

Cutaneous Nerves of the Shoulder.—A block should now be placed in the axilla, and the skin removed from

the upper and outer aspects of the shoulder as low down as the insertion of the deltoid. Commence in front and proceed from before backwards, taking care to leave the fatty superficial fascia in its place.

In the superficial fascia, which is thus laid bare, cutaneous nerves from two different sources must be secured and traced, in order that the area of skin supplied by each may be recognized. They are:—

1. Supra-acromial branches from the third and fourth cervical nerves.
2. Cutaneous branches from the circumflex nerve.

The *supra-acromial* branches have already been observed crossing the outer third of the clavicle and the insertion of the trapezius under cover of the platysma. They have been divided in removing the limb. If the cut ends be secured and followed, they will be found to spread out over the outer and back part of the upper portion of the deltoid region.

The *cutaneous branches* of the *circumflex nerve* consist—(*a*) of a large branch which turns round the posterior border of the deltoid muscle, and (*b*) of several fine filaments from the same source, which pierce the substance of the deltoid muscle, and appear at irregular intervals on its surface. The latter are difficult to secure, but the main branch can be easily found by carefully dividing the superficial fascia along the posterior border of the deltoid. On everting this border very little dissection is required to expose the nerve hooking round it about two and a-half inches above the deltoid insertion. It breaks up into branches which supply the skin over the lower portion of the deltoid region.

Deep Fascia.—A firm but thin fascia covers the subscapularis muscle. Into this some of the fibres of the serratus magnus will usually be found inserted at the vertebral border of the scapula. The strongest and most

conspicuous fascia in this region is that which covers the exposed part of the infraspinatus muscle. It is firmly attached to the limits of the fossa in which that muscle lies, and presents other very apparent connections. Thus a strong septum will be noticed to dip in between the infraspinatus and teres minor, and then as it proceeds forwards it gives a thin covering to the teres minor, teres major, and the deltoid. Indeed it may be said to split into two lamellae—a superficial and a deep—which as they pass forwards enclose between them the deltoid muscle.

Deltoid Muscle.—Depress the scapula and retain it in this position by means of hooks. The fibres of the deltoid are thus rendered tense, and the coarse fasciculi of the muscle may be cleaned.

The *deltoid muscle*, as its name implies, is triangular in form. It is composed of coarse fasciculi and covers the shoulder-joint. It arises from the anterior border of the outer third or half of the clavicle, from the outer border of the acromion process, and from the lower border of the spine of the scapula. Its origin closely corresponds with the insertion of the trapezius. The fasciculi of which the muscle is formed converge rapidly as they are traced downwards, and finally they present a pointed tendinous insertion into the *deltoid eminence* on the middle of the outer surface of the shaft of the humerus.

The arrangement of the fibres in the deltoid is very complicated. In the *anterior* or *clavicular* part the fibres are parallel and fleshy. In the *posterior* part, which springs from the scapular spine, the fibres are also fleshy, and arise partly from bone and partly from the fascia covering the muscle, which in this locality is very dense and aponeurotic in its character. The *intermediate* or *acromial* part arises partly by fleshy fibres, which spring directly from the bone, and partly by three or four tendinous septa, which may be called *septa of origin*. Its insertion is likewise partly fleshy and partly by three or four tendinous septa (*septa of insertion*). The muscular fibres, which arise

from the sides of the septa of origin, pass obliquely downwards into the sides of the septa of insertion. The muscular fibres, which arise directly from the acromion process, are inserted into the upper extremities of the septa of insertion. Lastly, certain fibres, which spring from the

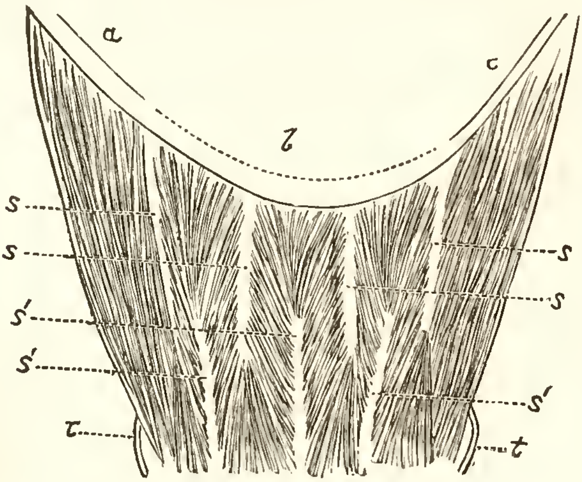

FIG. 10.

Diagram, showing the arrangement of the Fibres of the Deltoid Muscle.

a Part of the muscle which springs from the spine of the scapula; *b* Acromial portion; *c* Clavicular part; *s* Septa of origin; *s′* Septa of insertion; *t* Tendon of insertion.

extremities of the septa of origin, pass directly to the humerus between the septa of insertion. The arrangement will be better understood by referring to the accompanying diagram.

Quadrilateral Space.—The limb should now be placed on its posterior aspect, and the posterior circumflex artery and the circumflex nerve traced backwards through the quadrilateral space. The boundaries of the space at the same time should be defined and cleaned. The space in question is purely the result of dissection; it has no real existence until the parts are artificially separated from each other. When viewed from the front, the boundaries will be seen to be formed by—(*a*) the upper part of the shaft of the humerus *externally*; (*b*) the long head of the triceps

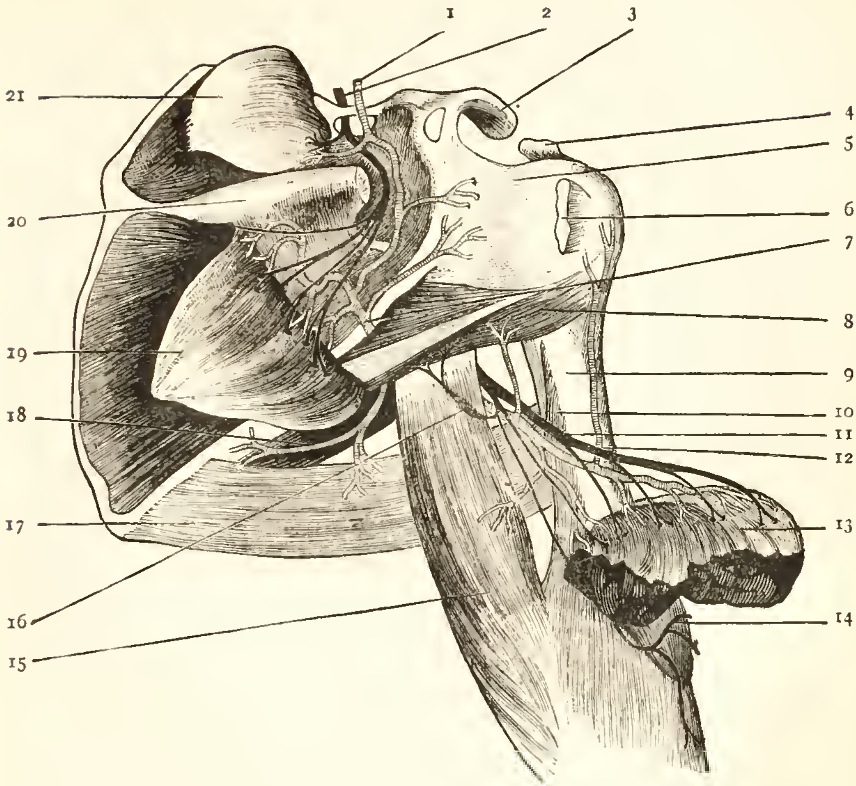

FIG. 11.

Dissection of the Posterior Scapular Region.

1. Suprascapular artery.
2. Suprascapular nerve.
3. Coracoid process.
4. Tendon of supraspinatus.
5. Capsule of shoulder-joint.
6. Tendon of infraspinatus.
7. Dorsalis scapulæ artery.
8. Teres minor.
9. Shaft of the humerus. (Surgical neck.)
10. External head of triceps.
11. Circumflex nerve.
12. Posterior circumflex artery.
13. Deltoid.
14. Cutaneous branch of the circumflex nerve.
15. Long head of triceps.
16. Nerve to teres minor.
17. Teres major.
18. Infrascapular branch of dorsalis scapulæ artery.
19. Infraspinatus.
20. Spine of scapula. (The acromion process has been sawn off.)
21. Supraspinatus.

Note the triangular and quadrilateral spaces as seen from behind.

internally; (*c*) the lower margin of the subscapularis *above;* (*d*) and the upper border of the teres major *below.* The term *triangular space* is the name given to another intermuscular interval which becomes apparent when the muscles in this region are cleaned and separated. It is placed nearer the inferior angle of the scapula, and the long head of the triceps intervenes between it and the quadrilateral space. It is bounded *above* by the subscapularis; *below* by the teres major; and *externally* by the long head of the triceps. The *dorsalis scapulæ artery* should be followed into this space, and cleaned up to the point where it disappears around the axillary border of the scapula under cover of the teres minor.

Having now traced the posterior circumflex artery and the circumflex nerve as far as possible through the quadrilateral space, the position of the limb should be reversed. Turn it now so that its dorsal surface is uppermost, and everting slightly the posterior border of the deltoid, define the boundaries of the space as they are seen from behind. At the same time clean the circumflex vessels and nerves as they issue from the space to reach the deep surface of the deltoid muscle. Care must be taken not to injure the branch which the circumflex nerve gives to the teres minor. When viewed from behind, the *upper boundary* of the quadrilateral space will be seen to be formed by the teres minor; the other boundaries are the same as were seen in front.

Reflection of the Deltoid.—Divide the muscle close to its origin and throw it downwards; in doing this preserve the acromial branch of the thoracic axis which runs in the line of incision beneath the deltoid. A large bursa which lies between the deltoid and upper aspect of the capsule of the shoulder joint must also be kept intact.

The deltoid covers the upper part of the humerus, and is wrapped round the shoulder-joint so as to envelop it behind, externally, and in front. The full rounded appearance of the shoulder will now be seen

to be due to the muscle passing over the expanded upper end of the humerus. When the head of the bone is displaced the muscle passes more or less vertically downwards from its insertion, and the dislocation is recognized by the squareness or flatness of the shoulder. Behind, the deltoid covers the muscles which arise from the dorsal aspect of the scapula as they pass outwards to reach the great tuberosity of the humerus; in front, it covers the upper part of the biceps muscle, and overlaps the coracoid process and the muscles attached to it. In relation also to the deep surface of the deltoid are the circumflex vessels and nerves.

Subacromial Bursa.—This is a large bursal sac which intervenes between the acromion process and deltoid above, and the upper aspect of the capsule of the shoulder-joint below. It facilitates the play of the upper end of the humerus with its capsule, on the under aspect of the acromion process and deltoid. Pinch a portion of it up with the forceps and make an incision into it.* The finger may then be introduced into its interior and its extent and connections explored. In some cases it is divided by internal partitions into two or more chambers or loculi.

Circumflex Vessels and Nerve.—The branches of the posterior circumflex artery and the circumflex nerve should now be dissected out on the deep surface of the deltoid muscle.

The *posterior circumflex artery* has been already observed to arise within the axilla from the posterior aspect of the axillary artery a short distance below the subscapular branch. It at once proceeds backwards through the quadrilateral space, and winding round the surgical neck of the humerus, it is distributed in numerous branches to the deep surface of the deltoid muscle. Several twigs are also given to the shoulder-joint and the integument. It anastomoses with the acromial branch of the thoracic

* If the wall of the bursa be quite entire a blowpipe may be thrust into it. It can then be distended, and if unilocular it may be inflated to about the size of a hen's egg. It varies, however, much in size in different individuals; and also under different conditions of age.

axis and the anterior circumflex artery, and also by one or more twigs which it sends downwards to the long head of the triceps, with the superior profunda branch of the brachial.

The termination of the *anterior circumflex artery* can now be more satisfactorily studied, and its anastomosis with the posterior circumflex established if the injection has flowed well. By this anastomosis the arterial ring which encircles the upper part of the shaft of the humerus is completed.

The *circumflex nerve* accompanies the posterior circumflex artery, and supplies—(*a*) *muscular branches* to the deltoid and teres minor; (*b*) *cutaneous branches* to the skin over the lower part of the deltoid; and (*c*) an *articular twig* to the shoulder-joint. The following is the manner in which it is distributed. It springs from the posterior cord of the brachial plexus, and turning round the lower border of the subscapularis, proceeds backwards with the posterior circumflex artery in the quadrilateral space. Reaching the posterior aspect of the limb, it divides into an anterior and a posterior division. The *articular branch* takes origin from the trunk of the nerve, and enters the joint below the subscapularis muscle. The *posterior division* gives off the branch to the teres minor, and after furnishing a few twigs to the posterior part of the deltoid, is continued onwards as the cutaneous nerve which has already been dissected in the superficial fascia over the lower part of the deltoid. The nerve to the teres minor is distinguished by the presence of an oval gangliform swelling upon it. The *anterior division* proceeds round the humerus with the posterior circumflex artery, and ends near the anterior border of the deltoid. It is distributed by many branches to the deep surface of this muscle, and a few fine filaments piercing the deltoid reach the skin.

Teres Major—Insertions of Latissimus Dorsi and Pectoralis Major.—The part which the teres major plays in the

formation of the quadrilateral and triangular spaces has already been seen. The student must now examine its attachments. It arises from the oval surface on the dorsum of the scapula close to the inferior angle of the bone, and also from the septa which the fascia infraspinata sends in to separate it from the infraspinatus and teres minor muscles. It is inserted into the inner lip of the bicipital groove on the upper part of the humerus.

The narrow, band-like tendon of the latissimus dorsi lies in front of the insertion of the teres major. From the lower margin of this a small fibrous slip will be observed passing downwards, beyond the lower margin of the teres major, to find attachment to the long head of the triceps. This is a rudiment of the dorsi-epitrochlearis muscle of the lower animals. The tendons of the teres major and latissimus dorsi should now be separated from each other. They will be found to be more or less adherent, and a small bursa will be discovered between them. The insertion of the latissimus dorsi into the bottom of the bicipital groove of the humerus may now be satisfactorily studied.

The tendon of insertion of the *pectoralis major*, which is attached to the outer lip of the bicipital groove, may also be conveniently examined at this stage (p. 25). A separation of the sternal and clavicular portions of the muscle will bring into view the two laminae which constitute the tendon, and the following points may be noted in connection with these :—(*a*) that they are continuous with each other below, or, in other words, that the tendon is simply folded upon itself; (*b*) that the posterior lamina extends upwards on the humerus to a higher level than the anterior, and that a fibrous expansion proceeds upwards from its superior border, to seek attachment to the capsule of the shoulder-joint and the lesser tuberosity of the humerus; (*c*) that the lower border is connected with the fascia of the upper arm.

Acromio-clavicular Articulation.—This is a diarthrodial joint, and the ligaments which bind the bones together are :—

Ligaments proper to the joint, ...	1. Superior 2. Inferior	capsule.
Accessory ligaments—Coraco-clavicular	trapezoid. conoid.	

The *superior acromio-clavicular ligament* is a broad band, composed of stout fibres, which is placed on the upper aspect of the joint. The *inferior acromio-clavicular ligament* which closes the joint below is not so strongly developed. In front and behind these ligaments are connected with each other so as to constitute a capsule. The joint should now be opened, when it will be seen to be lined by a synovial membrane. An imperfect *interarticular fibro-cartilage* is also usually present. It is wedge-shaped, and connected by its base to the superior ligament, whilst its free margin is directed downwards between the bones.

The Coraco-clavicular Ligament is very powerful. It binds the under surface of the clavicle to the base of the coracoid process. When thoroughly cleaned and defined it will be seen to consist of two parts, which are termed respectively conoid and trapezoid.

The *conoid ligament*, placed upon the posterior and inner aspect of the trapezoid, is broad above where it is attached to the conoid tubercle of the clavicle, and somewhat narrower below at its attachment to the inner part of the root of the coracoid process. The *trapezoid ligament* is the anterior and external part. Above it is attached along the trapezoid line of the clavicle, whilst below it is fixed to the upper aspect of the coracoid process. In the recess between these two ligaments a bursa will usually be found.

Coraco-acromial Arch.—It is necessary to examine this arch at the present stage, as the next step in the dissection will, in a great measure, destroy it. It is the arch which overhangs the shoulder-joint and protects it from above.

It is formed by the coracoid process, the acromion process, and a ligament—the coraco-acromial—which stretches between them.

The *coraco-acromial ligament* is a strong band of a somewhat triangular shape. By its base it is attached to the outer border of the coracoid process, whilst by its apex it is attached to the extremity of the acromion.

The coraco-acromial arch plays a very important part in the mechanism of the shoulder. It might almost be said to form a secondary socket for the humerus, and has been named the '*voute protectatrice*' by Blaudin. We have already noted the large bursa which intervenes between the acromion and the capsule of the shoulder-joint, to facilitate the movements.

Supraspinatus.—The supraspinatus, infraspinatus, and teres minor muscles, which arise from the dorsum scapulæ, and the subscapularis, which takes origin from the venter scapulæ, may now be examined.

In order to obtain an uninterrupted view of this muscle, the acromion process must be divided with the saw close to its junction with the spine of the scapula (Fig. 11.) The supraspinatus muscle arises from the inner two-thirds of the supraspinous fossa, and also to a slight degree from the fascia supraspinata which covers it. From this origin the fibres converge as they pass outwards, and, proceeding under the acromion process, they end in a short, stout tendon, which is inserted into the uppermost of the three impressions on the great tuberosity of the humerus. This tendon is closely adherent to the capsule of the shoulder-joint. The supraspinatus is covered by the trapezius, and in the loose fat which intervenes between this muscle and the fascia supraspinata some twigs of the superficial cervical artery ramify.

The Teres Minor is the small muscle which lies along the lower border of the infraspinatus. Divide the fascia which covers it, and reflect it towards the infraspinatus.

By this means the septum from the fascia infraspinata, which dips in between the two muscles, will be demonstrated, and their separation rendered easy. Care must be taken not to injure the dorsalis scapulæ artery which passes between the teres minor and the bone. The teres minor arises from an elongated flat impression on the dorsal aspect of the axillary border of the scapula, and from the septa of the fascia infraspinata which intervene between it, the infraspinatus and teres major muscles. It is inserted into the lowest of the three impressions on the great tuberosity of the humerus, and also, by fleshy fibres, into the shaft of the bone for about half an inch below this. Towards its insertion it is separated from the teres major by the long head of the triceps.

The Infraspinatus arises from the whole of the infraspinous fossa, with the exception of a small part of it near the neck of the scapula. It also derives fibres from the fascia which covers it. Its tendon of insertion is closely adherent to the capsule of the shoulder-joint, and is attached to the middle impression on the great tuberosity of the humerus. The central fibres, which constitute the greater part of the muscle, end directly in the tendon; the upper and lower fibres are inserted into the dorsal aspect of the tendon, and, in a measure, hide it from view. The upper fibres, arising from the under aspect of the scapular spine, constitute a very distinct fasciculus.

The Subscapularis arises from the whole of the subscapular fossa, with the exception of a small portion near the neck of the scapula; it also takes origin from the groove which is present on the ventral aspect of the axillary border of the bone. Its origin is strengthened by tendinous intersections, which are attached to the ridges which are present on the venter scapulæ. The fleshy fibres thus derived converge upon a stout tendon, which is inserted into the lesser tuberosity of the humerus;

a few of the lower fibres, however, gain independent insertion into the shaft of the humerus below the tuberosity. As the muscle proceeds outwards to its insertion, it passes under an arch formed by the coracoid process and the conjoined origin of the short head of the biceps and coraco-brachialis. By dissecting between the upper border of the muscle and the root of the coracoid process, a bursa of some size will be discovered. This bursa communicates with the cavity of the shoulder-joint through an aperture in the capsular ligament: in other words, it is directly continuous with the synovial membrane which lines the joint. This can readily be ascertained by making an incision through its wall. An instrument can then be passed into the joint.

The Suprascapular Artery and Nerve must now be followed to their distribution on the dorsum of the scapula. They have already been traced to the upper border of the scapula. Divide the infraspinatus muscle about an inch and a-half from its insertion, taking care not to injure the subjacent vessels. Pull the muscle cautiously backwards, and its nerve of supply with the terminations of the suprascapular and dorsalis scapulæ vessels will be exposed. Treat the supraspinatus muscle in a similar manner (Fig. 11, p. 53.)

The *suprascapular artery* enters the supraspinous fossa by passing over the ligament which bridges across the suprascapular notch. It divides, under cover of the supraspinatus muscle, into a *supraspinous* and an *infraspinous* branch. The former supplies the supraspinatus muscle, and gives off the chief nutrient artery to the scapula; the latter proceeds downwards in the great scapular notch, and under cover of the spino-glenoid ligament, to reach the deep surface of the infraspinatus muscle to which it is distributed.

At the upper border of the scapula the suprascapular artery gives off a branch (the *subscapular*) which enters

the subscapular fossa under cover of the subscapularis muscle.

The *suprascapular* nerve accompanies the artery of the same name, but it enters the supraspinous fossa by passing through the suprascapular notch, under cover of the suprascapular ligament. It supplies the supraspinatus, and ends in the infraspinatus muscle. It usually sends *two articular* twigs to the posterior aspect of the shoulder-joint, viz., one while in the supraspinous fossa, and the second as it lies in the infraspinous fossa.

Dorsalis Scapulæ Artery.—This vessel has already been observed to arise from the subscapular branch of the axillary, and enter the triangular space. While here, it supplies one or two *ventral branches*, which pass under cover of the subscapularis muscle to the venter scapulæ, and a larger *infrascapular branch* which runs downwards in the interval between the teres major and minor to the inferior angle of the scapula. After these branches are given off, the dorsalis scapulæ leaves the triangular space by turning round the axillary border of the scapula, under cover of the teres minor. It now enters the infraspinous fossa, where it ramifies and supplies branches to the infraspinatus muscle.

Anastomosis around the Scapula.—A very important and free anastomosis takes place around the scapula. Three main blood-vessels take part in this, viz.—(*a*) the suprascapular; (*b*) the posterior scapular; and (*c*) the subscapular.

The *posterior scapular artery* runs downwards in relation to the base or vertebral border of the scapula, and dispenses branches upon both the dorsal and ventral aspects of the bone. The *subscapular artery* runs downwards and inwards along the axillary border of the scapula, and at the inferior angle some of its terminal branches anastomose with the terminal twigs of the posterior scapular. The *suprascapular artery* at the upper margin of the

scapula is brought into communication with the posterior scapular by an anastomosis in the neighbourhood of the superior angle of the bone.

But still more distinct anastomoses take place upon the dorsal and ventral aspects of the bone. In the supraspinous fossa branches of the suprascapular inosculate with twigs from the posterior scapular; whilst in the infraspinous fossa free communications are established between the dorsalis scapulæ, the suprascapular, and the posterior scapular.

On the ventral aspect of the scapula, the ventral branch of the suprascapular, the ventral branches of the dorsalis scapulae, and the ventral branches of the posterior scapular, join to form a network.

The importance of this free communication between the blood-vessels in relation to the scapula will be manifest when it is remembered that two of the main arteries, viz. the posterior scapular and the suprascapular, spring indirectly from the first part of the subclavian, whilst the third, viz. the subscapular, arises from the third part of the axillary. When, therefore, a ligature is applied to any part of the great arterial trunk of the upper limb, between the first stage of the subclavian and the third part of the axillary, this anastomosis affords the most ample means of re-establishing the circulation.

Dissection.—Detach the subscapularis from the scapula and lift it outwards to its insertion. This will afford a better view of its relation to the capsule of the shoulder-joint, and also of the subscapular bursa. In a well-injected subject the ventral anastomosis can likewise be made out.

Suprascapular and Spino-glenoid Ligaments.—These are two ligamentous bands, which are placed in relation to the suprascapular artery and nerve. The *suprascapular* or *transverse ligament* bridges across the suprascapular notch of the scapula, and converts it into a foramen. It lies between the artery and nerve; the former being placed above it, and the latter below it. Not unfrequently it is ossified. The *spino-glenoid ligament* is a weaker band, which bridges across

the suprascapular artery and nerve as they pass through the great scapular notch. On the one hand it is attached to the spine of the scapula, and on the other to the upper part of the neck of the scapula.

FRONT OF THE ARM.

In this dissection the following parts have to be studied :—

1. Cutaneous vessels and nerves.
2. Brachial aponeurosis.
3. Brachial artery and its branches.
4. Median, ulnar, musculo-spiral, and musculo-cutaneous nerves and the branches of the two last.
5. Biceps, coraco-brachialis, and brachialis anticus muscles.

In conjunction with this dissection, it is convenient to study the triangular space in front of the elbow, and also to trace the cutaneous nerves to their ultimate distribution in the skin of the forearm.

Surface Anatomy.—In a muscular limb the prominence formed by the biceps muscle along the front of the upper arm is very apparent. Everyone is familiar with the rounded swelling which it produces when powerfully contracted in the living subject. On either side of the biceps there is a feebly-marked furrow, and ascending in each of these there is a large superficial vein. In the outer furrow is the cephalic vein ; in the inner furrow the basilic vein. The humerus is thickly clothed by muscles ; but towards its lower part the two supracondyloid ridges, leading down to the condylar eminences, may be felt. The external ridge is the more salient of the two, and therefore the more evident to touch.

But by far the most important objects for us to distinguish are the bony points around the elbow. It is by a proper knowledge of the normal relative positions of these that the surgeon is able to distinguish between the diffe-

rent forms of fracture and dislocation which so frequently occur in this region. First note the internal condyle of the humerus. This constitutes a prominence, appreciable to the eye; grasp it between the finger and thumb, and note that it inclines backwards as well as inwards. In a well-developed arm, when fully extended,

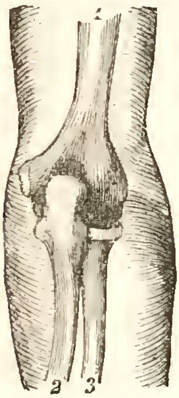

FIG. 12.

Posterior view of the upper limb, with the elbow-joint fully extended (Luschka).

1. Humerus.
2. Ulna.
3. Radius.

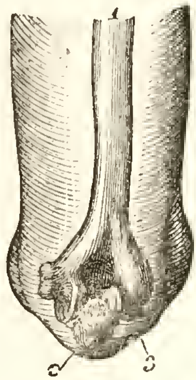

FIG. 13.

Posterior view of limb, with the elbow joint flexed (Luschka).

1. Humerus.
2. Ulna.
3. Radius.

the external condyle does not form a projection on the surface, but can be felt at the bottom of a slight depression on the posterior aspect of the limb. It becomes apparent to the eye as a prominence when the elbow is semi-flexed. The olecranon process of the ulna produces a marked projection on the back of the elbow between the two condyles. It is placed slightly nearer to the internal than to the external condyle. This is more especially the case in children—an important practical point, seeing that in the young injuries of the elbow are particularly common. The loose skin which covers the olecranon moves freely

over its subcutaneous surface, owing to the interposition of a synovial bursa. The different positions which are assumed by the olecranon, in relation to the condyles of the humerus in the movements of the forearm at the elbow-joint, must be carefully studied and considered. This can best be done by placing the thumb on one condyle, the middle finger on the other, and the forefinger on the olecranon. The limb should then be alternately flexed and extended, so as to make clear the limits of the excursion performed by the olecranon.* When the arm is extended the head of the radius may be easily felt on the back of the limb, immediately below the external condyle, and when the movements of pronation and supination are alternately induced it will be felt to roll under the finger.

As the skin of the forearm must be reflected in the pursuit of the cutaneous nerves, it is well, at this stage, to study also the external anatomy of this segment of the limb. In its upper half the radius is deeply imbedded in muscles ; but in its lower half it can be felt, and its styloid process on the outer side of the wrist can be readily distinguished. The sinuous posterior border of the ulna is subcutaneous, and may be followed by the finger throughout its entire length. In cases of fracture, therefore, it affords valuable information. The styloid process may be detected, and it should be observed that this does not extend so low down as the corresponding process of the radius. The rounded lower end of the ulna makes a marked projection on the inner and posterior aspect of the limb immediately above the wrist-joint.

Reflection of Skin.—The skin should be removed from the limb as far down as the wrist-joint. It is necessary to do this in order that a connected view

* In full extension at the elbow-joint the three prominences are placed on the same straight line; when the forearm, however, is bent at a right angle the three bony points are placed at the angles of an equilateral triangle, the apex of which points downwards.

may be obtained of the cutaneous nerves and the superficial veins. But at the same time the skin should not be cast aside, as it forms a most efficient protective wrapping for the part even after it has been detached. Make one long incision along the middle of the fore aspect of the arm and the forearm down to the wrist. A second incision, carried transversely round the lower end of the forearm immediately above the wrist-joint, will enable the dissector to reflect the skin in two large flaps, outwards and inwards. In the fatty superficial fascia, which is then exposed, the superficial structures may be traced. It is well to begin with the nerves, as these are not so apparent, and therefore more liable to injury than the veins. But the dissection of the veins should be carried on concurrently with that of the nerves.

Cutaneous Nerves.—These are very numerous, and are derived from several sources. In addition to the two internal cutaneous nerves, and the terminal cutaneous part of the musculo-cutaneous, which spring from the brachial plexus, there are three branches derived from the musculo-spiral, and one—the intercosto-humeral—from the second intercostal nerve. These seven nerves may be classified into an inner and an outer group as follows:—

1. Upper external cutaneous branch of musculo-spiral, 2. Lower external cutaneous branch of musculo-spiral, 3. Cutaneous part of musculo-cutaneous,	Distributed upon the outer aspect of arm and forearm.
1. Intercosto-humeral, 2. Internal cutaneous branch of musculo-spiral, 3. Lesser internal cutaneous, 4. Internal cutaneous,	Distributed upon the inner aspect of arm and forearm.

The two *external cutaneous branches of the musculo-spiral* pierce the deep fascia about the middle of the outer

surface of the upper arm immediately below the insertion of the deltoid, and in close relation to the external inter-

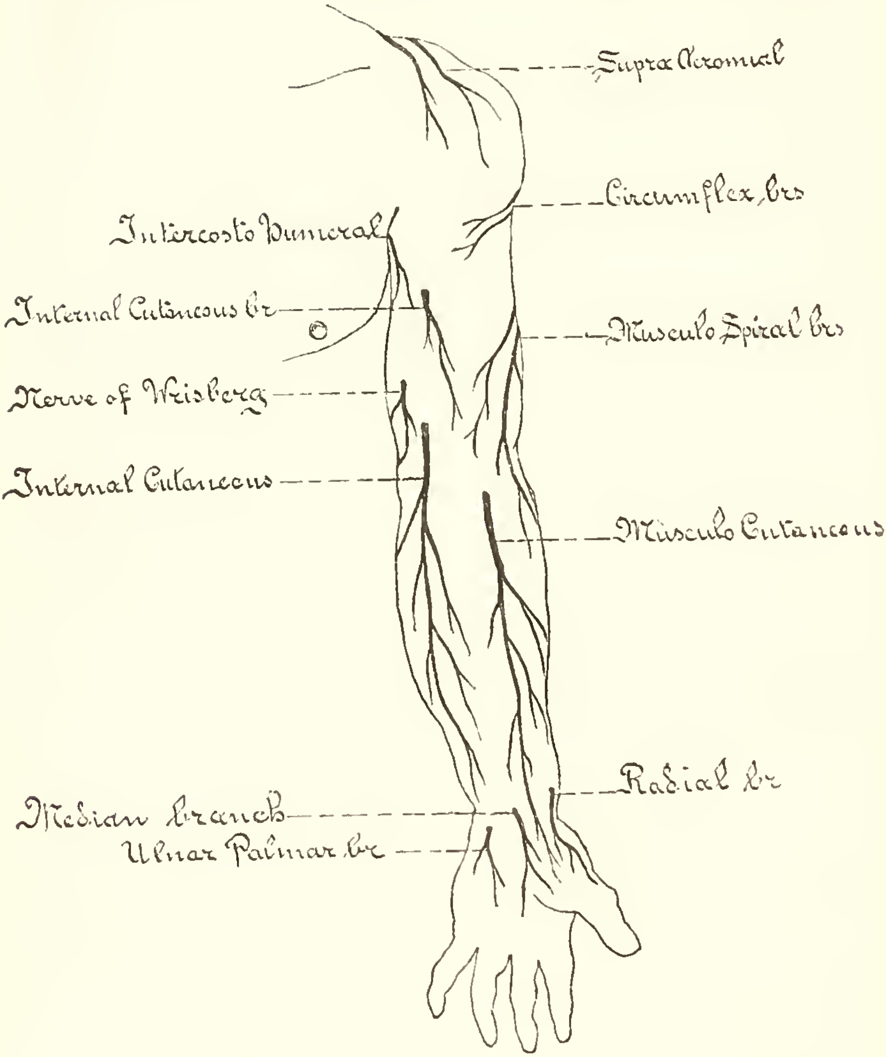

FIG. 14.

Diagram of the Cutaneous Nerves on the Anterior Aspect of the Limb.

muscular septum. The *upper* and smaller branch appears a short distance above the other. It follows the cephalic

vein, and can be traced downwards as far as the elbow. Its filaments are distributed to the skin over the outer and anterior part of the lower half of the upper arm. The larger *lower branch* can be followed as far as the wrist, and not unfrequently its terminal filaments may even reach the dorsum of the hand. It supplies the skin on the outer and dorsal aspects of the lower half of the upper arm and of the forearm.*

The terminal *cutaneous branch of the musculo-cutaneous* will be found in front of the elbow-joint. It pierces the deep fascia on the outer side of the tendon of the biceps. It is a large nerve, and proceeds downwards behind the median cephalic vein. The skin both upon the anterior and posterior aspects of the outer side of the forearm is supplied by this nerve, and it is distributed by two main branches. The *anterior* and larger branch can be traced as far as the skin over the ball of the thumb. A few of its terminal twigs pierce the fascia above the wrist, and join the radial artery, by which they are conducted to the back of the carpus. The *posterior branch* may be followed on the dorsal aspect of the limb as far as the wrist.

The cutaneous nerves on the inner aspect of the limb should now be dissected. Begin by tracing downwards to the back of the upper arm the intercosto-humeral, and the internal cutaneous branch of the musculo-spiral. These nerves have already been secured in the dissection of the axilla.

The *intercosto-humeral* can usually be traced half way down the upper arm; but the area of skin which it supplies is somewhat variable. The *internal cutaneous branch of the musculo-spiral* proceeds downwards and backwards on a deeper plane, and crosses under the intercosto-humeral.

* It should be borne in mind that the skin on the outer aspect of the limb, above these nerves and over the deltoid, is supplied by the cutaneous branches of the circumflex nerve and the supra-acromial branches of the cervical plexus (p. 50).

Its filaments extend upon the back of the upper arm as low as the elbow-joint.

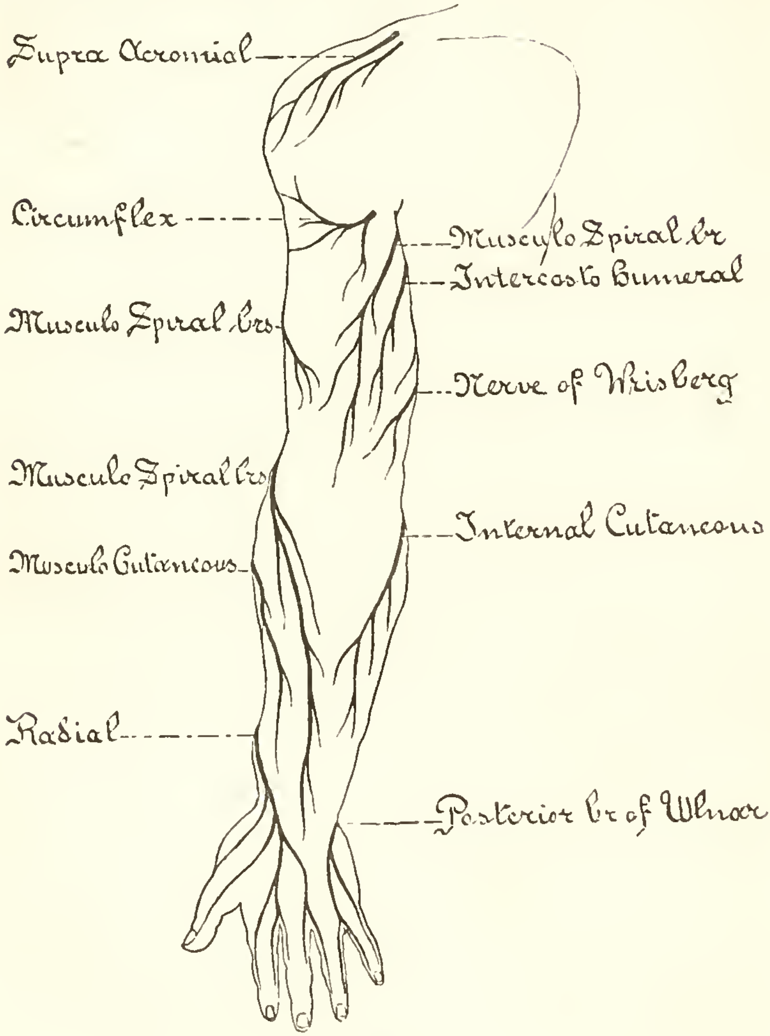

FIG. 15.

Diagram of the Cutaneous Nerves on the Posterior Aspect of the Limb.

The *small internal cutaneous nerve*, or *nerve of Wrisberg*, will be found piercing the deep fascia, to become super-

ficial, halfway down the inner side of the upper arm. Its twigs may be followed, in the superficial fascia, as far as the olecranon process.

On the inner side of the upper arm, on its dorsal aspect, three nerves therefore have been traced. From within outwards these are : the nerve of Wrisberg, the intercosto-humeral, and the inner cutaneous branch of the musculo-spiral (Fig. 15.)

The *internal cutaneous nerve* is chiefly destined for the supply of the skin of the forearm. It appears through the deep fascia half-way down the inner side of the upper arm close to the basilic vein, and a short distance in front of the nerve of Wrisberg. It at once divides into an anterior and a posterior branch. The *anterior branch* runs downwards behind (but sometimes in front of) the median basilic vein, and it is distributed to the skin over the inner and anterior aspect of the forearm. The *posterior branch*, inclining inwards, proceeds downwards in front of the internal condyle of the humerus, to reach the skin on the inner and dorsal aspect of the forearm.

A small twig is frequently given by the internal cutaneous to the skin over the biceps muscle. This pierces the deep fascia close to the axilla.

Superficial Veins.—The superficial veins in front of the forearm and upper arm may now be followed; but in all probability they are already for the most part exposed.

Four veins will be seen ascending upon the anterior and lateral aspects of the forearm, viz. the *radial vein* upon the outer border; the *anterior* and *posterior ulnar veins* upon the inner border; and the *median vein* upon the front of the forearm. When the median reaches the hollow in front of the elbow, it is joined by a short wide vein, which appears through the fascia, and establishes a connection between the median and the deep veins of the forearm. This connecting trunk is called the *pro-*

funda vein. After receiving this tributary, the median at once divides into two branches, which diverge widely from each other, like the limbs of the letter V. The inner branch is called the median-basilic; the outer the median-cephalic.

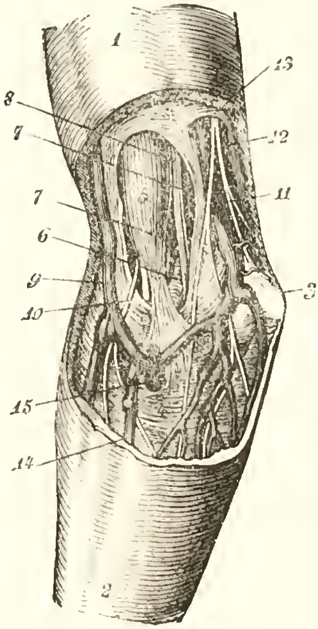

FIG. 16.

Superficial Dissection of the Region in front of the Elbow (Luschka).

1. Prominence of the biceps.
2. Forearm.
3. Internal condyle of humerus.
4. Deep fascia.
5. Biceps.
6. Brachial artery.
7. Brachialis anticus muscle.
8. Median nerve.
9. Cephalic vein.
10. Cutaneous terminal branch of musculo-cutaneous nerve.
11. Basilic vein
12. Internal cutaneous nerve. (The posterior branch of this nerve is represented as passing behind the internal condyle of the humerus. This is not correct, as it lies in front of that prominence.)
13. Deep fascia of upper arm.
14. Median vein.
15. Profunda vein.

The *median-basilic* is a short wide vessel which passes upwards and inwards, and as it approaches the front of

the internal condyle of the humerus it is joined by the two ulnar veins. These may enter it separately; but more commonly the anterior ulnar vein joins the larger posterior ulnar vein in the upper part of the forearm, so as to form a common trunk, and thus a single opening into the median-basilic. The large vein, resulting from the union of the median-basilic and the two ulnar veins, is termed the *basilic vein*. The median-basilic is the vein which is commonly selected when the surgeon has recourse to venæsection, and formerly, when the practice of blood-letting was much more common than it is now, the relations of this vein were a matter of very high importance.* The dissector should observe the following points in regard to it:—(1) that it crosses a thickened piece of the deep fascia, termed the *bicipital fascia;* (2) that this fascia separates it from the brachial artery, which it also crosses; and (3) that the anterior part of the internal cutaneous nerve lies behind it, although in many cases it may cross in front of it.

The *median-cephalic* vein is not so large as the median-basilic, and it generally ascends with a greater degree of obliquity. It crosses always in front of the cutaneous branch of the musculo-cutaneous nerve, and is joined by the radial vein. The resulting trunk is called the *cephalic vein.*

The *basilic vein* runs upwards on the inner aspect of the upper arm in the slight furrow which marks the limb along the inner margin of the biceps. Half-way up the upper arm it disappears by piercing the fascia close to the spot where the internal cutaneous nerve emerges. At the lower border of the posterior wall of the armpit the basilic forms the axillary vein.

The *cephalic vein* ascends in the groove along the outer

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* Many surgeons prefer the median-cephalic vein for the purpose of venæsection, because, although it is smaller than the median basilic, and does not yield so free a flow of blood, it may be opened with much less risk.

margin of the biceps. Its further course has been previously noted. It extends upwards in the interval between the deltoid and the clavicular part of the pectoralis major. It dips backwards through the costo-coracoid membrane, crosses the first part of the axillary artery, and finally opens into the axillary vein.

Lymphatic Glands.—If the superficial fascia be searched upon the inner side of the limb, and immediately above the elbow, one or two minute lymphatic glands (Crookshank's glands) in relation to the basilic vein will be found. These are of interest to dissectors, as they are the first to enlarge and become painful in cases of dissection-wound.*

Brachial Aponeurosis.—The deep fascia should now be cleaned by the removal of the fatty superficial layer. It forms a continuous envelope around the upper arm, but at no point does it show a great density or strength. Above, it is continuous with the axillary fascia, and the fascia covering the pectoralis major and the deltoid. The tendons of these two muscles are closely connected with it—a certain proportion of their tendinous fibres running directly into it. Below, it is firmly fixed to the bony prominences around the elbow, and in front it receives an accession of fibres from the tendon of the biceps. These fibres constitute the bicipital or semilunar fascia, and form a very distinct band which, continuous with the fascia above and below, bridges across the brachial artery, and is lost upon the pronator radii teres muscle on the inner side of the forearm.

The brachial aponeurosis may be reflected by making an incision through it along the middle line of the front

* It may be well to state here, however, that 'dissection-wounds,' obtained in the dissecting-room, are exceedingly uncommon. The subjects are so carefully preserved that the danger is reduced to a minimum.

of the arm. In throwing the inner portion inwards, the dissector must leave the bicipital fascia in position. This may be done by separating it artificially from the general aponeurosis by an incision above and below it. By this dissection it will be made evident that septa or partitions pass in between the muscles from the deep surface of the investing brachial aponeurosis. Two of these possess a superior strength, and obtain direct attachment to the humerus. They are the external and internal intermuscular septa. The connections of these cannot be fully studied at present, but it is important that the student should understand their relations at this stage. In the course of the dissection of the upper arm they will gradually be displayed.

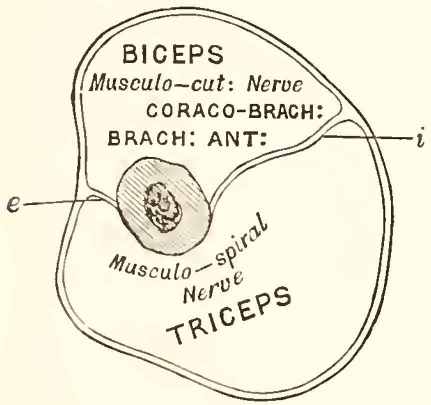

FIG. 17.

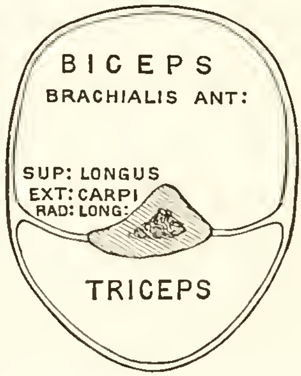

FIG. 18.

Diagrams (after Sir William Turner) to show how the upper arm is divided by the intermuscular septa and bone into an anterior and posterior compartment. These compartments are represented in transverse section. Fig. 17 represents a section about the middle of the forearm, and certain of the contents of the compartments at this level are indicated. *e* External intermuscular septum; *i* Internal intermuscular septum. In Fig. 4 the section is made a short distance above the elbow-joint.

The *internal intermuscular septum* is the stronger and more distinct of the two. It is attached to the internal supracondyloid ridge, and may be followed upwards as

high as the insertion of the coraco-brachialis muscle. The *external intermuscular septum* is fixed to the external supracondyloid ridge, and extends up the arm as high as the insertion of the deltoid. The dissector should note that these septa divide the upper arm into an anterior and a posterior osteo-fascial compartment.

Dissection.—The anterior osteo-fascial compartment of the upper arm has been opened into by the reflection of the front part of the brachial aponeurosis. The dissector should now proceed to clean the parts exposed. The three muscles which specially belong to this region are the biceps, brachialis anticus, and the coraco-brachialis. The biceps is the most superficial muscle: under cover of it, and closely applied to the anterior aspect of the humerus, is the brachialis anticus; whilst the coraco-brachialis is the slender muscular belly which lies along the inner side of the biceps in its upper part. But, in addition, two muscles of the forearm will be observed extending upwards into the arm, to seek origin from the external supracondyloid ridge: they are the supinator longus and the extensor carpi radialis longior. They are closely applied to the outer side of the brachialis anticus. The brachial artery, with its venæ comites, extends through the region in relation to the inner margin of the biceps, and all the terminal branches of the cords of the brachial plexus, with the exception of the circumflex, will be found for some part of their course in this dissection. The musculo-spiral, it is true, almost at once proceeds to the back of the limb, but it again comes to the front, and may be found in the lower part of the outer side of the arm, by separating the origins of the supinator longus and extensor carpi radialis longior from the brachialis anticus, and dissecting in the interval between them.

In carrying out this somewhat extensive dissection, the main object of the dissector should be to keep the brachial

artery as undisturbed as possible until he has satisfied himself as to its relations. He is therefore, in the first instance, advised to clean only those parts of the muscles which are in immediate relationship to the vessel and its branches. The divided brachial nerves, with the axillary artery and vein, should be arranged in proper order, and then tied to a small piece of wood about $1\frac{1}{2}$ inches long (*e.g.* a piece of a penholder), held transversely. By means of a loop of string this can then be fastened to the coracoid process. By this device the dissection of the upper arm will be greatly facilitated. The dissection of the entire length of the brachial artery should be carried out at one and the same time, and its termination in the radial and ulnar arteries should be defined.

Brachial Artery.—The brachial artery is the direct continuation of the axillary trunk into the upper arm. It therefore begins at the lower border of the teres major, and it proceeds downwards to a point a short distance below the bend of the elbow, where it ends opposite the neck of the radius by dividing into two terminal branches—the radial and the ulnar arteries. The course which it pursues is not a straight one: at first it lies upon the inner side of the limb, but it gradually, as it descends, inclines outwards so as to lie finally in front of the arm.

This change of direction must be borne in mind when pressure is applied to the vessel, with the view of controlling the flow of blood within it. Thus, above, the pressure must be directed in an outward and backward direction, so that it may be caught between the fingers and the bone; whilst below, the pressure must be applied in a backward direction.

Throughout its whole length, the brachial artery is superficial: in other words, in order to expose the vessel the skin and fascia alone would require to be removed. The inner margins of the coraco-brachialis and the biceps muscles, however, which lie along its outer side, overlap

it to a considerable extent, and finally, in the anticubital fossa, it sinks deeply in the interval between the supinator longus on the outside, and the pronator radii teres on the inside. The extent to which the brachial artery is overlapped by the biceps may be seen in the accompanying woodcut (Fig. 19). At the bend of the elbow it is crossed by

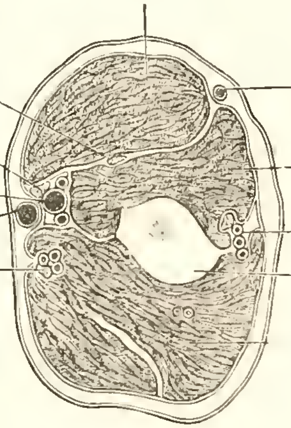

FIG. 19.

Transverse Section through the Right Upper Arm about its middle.

At this level it will be seen that the brachial artery and the median nerve lie in a deep furrow on the inner side of the limb bounded by the biceps, triceps, and brachialis anticus, reminding one somewhat of Hunter's canal in the lower limb.

the bicipital fascia, which, as previously stated, intervenes between it and the median-basilic vein. The basilic vein, in its lower part, is separated from the artery by the deep fascia. It does not lie immediately over it, but to its inner side (Fig. 19). Higher up, after the vein has pierced the fascia, it comes into closer relationship with the artery. Two venæ comites are closely applied to the brachial artery, and the numerous connecting branches which pass between the vein cross over and

under the vessel, so as to make the relationship still more intimate.

Behind, the brachial artery is supported by a succession of structures, as we trace it from above downwards. First, it lies in front of the long head of the triceps, but here the musculo-spiral nerve and the superior profunda artery are interposed; next, it rests upon the inner head of the triceps; then upon the insertion of the coraco-brachialis; and lastly, for the remainder of its course, upon the brachialis anticus.

With the exception of the musculo-cutaneous, all the large nerves of the arm will be seen to lie, for a certain part of their course, in relation to the brachial artery. The *median* accompanies it closely throughout its whole length. At first it lies in front, and to the outer side of the vessel; towards the middle of the arm it crosses superficially to the vessel; from this onwards it is placed along its inner side. The *ulnar* and *internal cutaneous* nerves lie close to its inner side, as far as the insertion of the coraco-brachialis, and then they leave the artery. The former inclines backwards, and, piercing the internal intermuscular septum, enters the posterior compartment of the arm. The internal cutaneous nerve, on the other hand, inclines forwards, and becomes superficial by piercing the brachial aponeurosis. The *musculo-spiral*, for a very short distance, is placed behind the brachial artery, as it lies in front of the long head of the triceps, but soon it leaves the vessel by disappearing in the interval between the long and inner heads of the triceps.

Branches of the Brachial Artery.—A considerable number of branches spring from the brachial artery. Those which arise from its outer aspect are irregular in number, origin, and size. They are termed the *external branches*, and are distributed to the muscles and integument on the front of the arm. The series of *internal branches* which proceed from the inner and posterior aspect of the parent

trunk are named as follows as we meet them from above downwards :—

1. Superior profunda.	3. Nutrient.
2. Inferior profunda.	4. Anastomotica magna.

The *superior profunda* is the largest of the branches which spring from the brachial trunk. It takes origin about an inch or so below the lower margin of the teres major, and associates itself with the musculo-spiral nerve, which it accompanies to the back of the arm. Consequently, only a short part of the vessel is seen in the present dissection. It soon disappears from view between the long and inner heads of the triceps.

The *inferior profunda* is a long slender artery, which can be recognized from the fact that it follows closely the course which is pursued by the ulnar nerve. Its origin is somewhat uncertain. As a general rule, it issues from the brachial artery opposite the insertion of the coraco-brachialis, but very frequently it will be seen to arise in common with the superior profunda. It pierces the internal intermuscular septum, with the ulnar nerve, and descends behind this aponeurotic partition to the interval between the olecranon and the internal condyle of the humerus.

The *nutrient artery* to the humerus may arise directly from the brachial trunk, or take origin from the inferior profunda. It should be sought for at the lower border of the coraco-brachialis, and the dissector should not be satisfied until he has traced it into the medullary foramen of the bone. When the nutrient artery is not seen in its usual position, it will probably be found in the dissection of the back of the arm, taking origin from the superior profunda. Henle describes this as the normal arrangement.*

* Of 81 humeri recently macerated in the Anatomical Department of Trinity College, 25 were found to possess two nutrient foramina, one at the outer border of the musculo-spiral groove, and the other below the insertion of the coraco-brachialis; in 42 the foramen below

The *anastomotica magna* arises about two inches above the bend of the elbow, and runs inwards upon the brachialis anticus. It soon divides into a small anterior and a larger posterior branch. The *anterior branch* is carried downwards in front of the internal condyle of the humerus in the interval between the brachialis anticus and the pronator radii teres. It anastomoses in this situation with the anterior ulnar recurrent artery. The *posterior branch* pierces the internal intermuscular septum, and will be seen later on in the posterior compartment of the arm.

The two internal Cutaneous Nerves.—Very little more requires to be said about these nerves. Their origin within the axilla has already been noted, and they have been traced to their distribution from the points where they pierce the investing brachial aponeurosis. It only remains for the dissector to examine them in that part of their course in which they lie under cover of the brachial aponeurosis. It will be observed that they both lie along the inner side of the brachial artery. The *nerve of Wrisberg*, or *lesser internal cutaneous nerve* gives off, as a rule, no branches in this situation, except one or more twigs of communication to the intercosto-humeral. The *internal cutaneous* gives off the branch which pierces the fascia to supply the skin in front of the biceps.

The Median and the Ulnar Nerves.—These large nerve-trunks do not furnish any branches in the upper arm. The *median* arises in the axilla by two heads from the outer and inner cords of the brachial plexus. It proceeds downwards upon the outer and superficial aspect of the axillary and brachial arteries, until it approaches the level

the insertion of the coraco-brachialis was the only one present, but it varied somewhat in position, being in 4 cases within two and a-half inches of the lower margin of the trochlea; in the remaining 4 humeri there was one foramen situated in the musculo-spiral groove.

of the insertion of the coraco-brachialis. Here it lies in front of the artery. Finally, it reaches the inner side of the vessel, and maintains this position for the rest of its course in the upper arm.

The *ulnar nerve* is the largest branch of the inner cord of the brachial plexus. It descends upon the inner side of the axillary and brachial arteries, and at the insertion of the coraco-brachialis it encounters the inferior profunda artery. Accompanied by this vesssel, it now leaves the brachial artery by passing backwards through the internal intermuscular septum, and it is continued downwards upon the posterior aspect of this aponeurotic partition, to the interval between the olecranon and internal condyle of the humerus.

Muscles and Musculo-cutaneous Nerve.—The muscles should now be thoroughly cleaned, and the musculo-cutaneous nerve and its branches dissected out.

The *musculo-cutaneous nerve* arises from the outer cord of the brachial plexus, at the lower border of the pectoralis minor. Inclining outwards, it perforates the coraco-brachialis, and appears between the biceps and the brachialis anticus. It proceeds obliquely downwards between these muscles until it reaches the bend of the elbow, where it comes to the surface at the outer border of the tendon of the biceps. From this point onwards it has already been traced as a cutaneous nerve of the forearm (p. 69).

In the upper arm the musculo-cutaneous supplies branches to the three muscles in this region. The branch to the coraco-brachialis is given off before the parent trunk enters the substance of the muscle; the branches to the biceps and brachialis anticus issue from it, as it lies between them.

A minute twig, which springs from the musculo-cutaneous, close to its origin, runs downwards upon the brachial artery, and breaks up into fine filaments, which accompany the nutrient artery into the humerus. Another fine filament is said to go to the elbow-joint. This arises from the branch to the brachialis anticus.

The Coraco-brachialis is an elongated muscle, which takes origin from the tip of the coracoid process in conjunction with the short head of the biceps. It proceeds downwards along the inner margin of the biceps, and obtains insertion into a linear ridge situated upon the inner aspect of the shaft of the humerus about its middle.

The Biceps Flexor Cubiti arises from the scapula by two distinct heads of origin. The *short* or *inner head* springs from the tip of the coracoid process in conjunction with the coraco-brachialis. The *long* or *outer head* is a rounded tendon, which occupies the bicipital groove of the humerus. Its origin cannot be studied at this stage of the dissection, because it is placed within the capsule of the shoulder-joint. Suffice it for the present to say, that it arises from an impression on the scapula immediately above the glenoid fossa. Both heads swell out into elongated fleshy bellies, which are closely applied to each other, and afterwards unite in the lower third of the arm. Towards the bend of the elbow the fleshy fibres converge upon a stout, short tendon, which is inserted into the posterior part of the tuberosity of the radius. This insertion will be more fully examined at a later period, but it may be noticed in the meantime that the tendon is twisted so as to present its margins to the front and back of the limb, and further, that a synovial bursa is interposed between it and the anterior smooth part of the radial tuberosity.

The dissector has already taken notice of the *bicipital* or *semilunar* fascia, and has separated it artificially from the brachial aponeurosis above, and from the deep fascia of the forearm below. Observe now that it springs from the anterior margin of the tendon, and that it likewise receives some muscular fibres from the short head of the muscle.

The Brachialis Anticus arises from the entire width of the anterior surface of the lower half of the shaft of the

humerus, from the internal intermuscular septum, and from a small part of the external intermuscular septum above the supinator longus. The origin from the bone is prolonged upwards in two slips which partially embrace the insertion of the deltoid. The fibres converge to be inserted into the base of the coronoid process of the ulna by a short, thick tendon. The muscle lies partly under cover of the biceps, but projects beyond it on either side. It is overlapped on its inner side by the pronator radii teres, and on the outer side by the supinator longus and extensor carpi radialis longior. Its deep surface is closely connected to the anterior ligament of the elbow-joint. Its chief nerve of supply, from the musculo-cutaneous, has already been secured, but it also receives one or two small twigs from the musculo-spiral, which are given off under cover of the supinator longus.

Dissection.—Separate the supinator longus muscle from the brachialis anticus, and dissect out the musculo-spiral nerve, and the anterior terminal branch of the superior profunda artery, which lie deeply in the interval between them. Here also the anastomosis between the superior profunda and the radial recurrent arteries may be made out, in a well injected subject; and the twigs which are given by the musculo-spiral nerve to the brachialis anticus, supinator longus, and extensor carpi radialis longior, looked for.

Triangular Space in front of the Elbow (Anticubital Fossa).—This is a slight hollow in front of the elbow-joint. It corresponds to the popliteal space of the lower limb, and within its area the brachial artery divides into its two terminal branches. In the first instance let the dissector consider the structures which cover it. These have already been removed, and consist of skin, superficial fascia, and deep fascia. In connection with the latter is the semilunar fascia, whilst within the superficial fascia are the median-basilic and median-cephalic veins, the anterior division of the internal cutaneous nerve and the

cutaneous part of the musculo-cutaneous nerve. These structures constitute the *coverings* of the space.

The space is triangular. Its *base* is directed upwards, and is usually regarded as being formed by a line drawn between the two condyles of the humerus. Its *inner boundary* is the pronator radii teres, and its *outer boundary* the supinator longus. The meeting of these two muscles below constitutes the *apex*. The boundaries should now be thoroughly cleaned, and then the *contents* of the space may be dissected.

Within the space, as we have already stated, there is the termination of the brachial artery, and the radial and ulnar branches into which it divides. To the outer side of the main vessel is placed the tendon of the biceps, and to its inner side the median nerve. A quantity of loose fat is also present. The ulnar artery leaves the space, by passing under cover of the pronator radii teres; the radial artery is continued downwards beyond the apex of the space, overlapped by the supinator longus. The median nerve disappears between the two heads of the pronator radii teres, and the tendon of the biceps inclines backwards between the two bones of the forearm, to reach its insertion into the radial tuberosity.

When the fatty tissue has been thoroughly removed the *floor* of the space will be revealed. This is formed by the brachialis anticus and the supinator brevis.

Now divide the bicipital fascia and separate the bounding muscles widely from each other. Other structures come into view, but they cannot, strictly speaking, be regarded as lying within the space proper. They are—(1) the musculo-spiral nerve, the anterior branch of the superior profunda artery, and the radial recurrent branch of the radial artery, lying deeply between the supinator longus and the brachialis anticus; (2) the anterior branch of the anastomotica magna, and the anterior ulnar recurrent branch of the ulnar artery, placed under cover of the pronator radii teres.

BACK OF THE ARM.

In this region the following are the structures which require to be studied :—

1. The triceps muscle.
2. The superior profunda artery, and the musculo-spiral nerve.
3. The inferior profunda artery, and the ulnar nerve.
4. The posterior branch of the anastomotic artery.
5. The subanconeus muscle.

Dissection.—The skin has already been removed from the back of the arm. The deep fascia should now be raised from the surface of the triceps muscle, and its three heads cleaned and isolated from each other. To place the muscle on the stretch, the inferior angle of the scapula should be raised as high as possible, and the forearm flexed at the elbow-joint. The musculo-spiral nerve, together with the superior profunda artery, must at the same time receive the attention of the dissector. They should be followed backwards between the heads of the triceps and all their branches should be carefully preserved.

Triceps Extensor Cubiti.—This muscle occupies the entire posterior osteo-fascial compartment of the upper arm. It arises by a *long* or *middle head* from the scapula, and by two short heads, *outer* and *inner*, from the humerus. The fleshy fibres of these three heads join a common tendon, which is inserted into the olecranon process of the ulna. The superficial part of the muscle is, for the most part, formed by the long scapular head and the outer humeral head of the muscle. The inner humeral head is deeply placed; only a very small portion of it appears superficially in the lower part of the arm on each side of the common tendon of insertion.

The *long* or *scapular head* of the triceps arises by a flat-

tened tendon, which spreads out so as to enclose the muscular substance of the fleshy belly, from the rough triangular impression on the upper part of the axillary border and the lower aspect of the neck of the scapula. This tendon takes origin in the interval between the teres minor and subscapularis muscles. From the lower border of the tendon of the latissimus dorsi muscle an aponeurotic slip proceeds, which joins the long head of the triceps upon its inner aspect. This slip has been already alluded to as a remnant of the dorsi-epitrochlearis muscle of the lower animals.

The *two humeral heads* take origin from the posterior aspect of the humerus, and if it be borne in mind that no fibres arise from the musculo-spiral groove, and that this groove intervenes between the origins of these heads, their connections will be easily understood. The dissector should provide himself with a humerus, and, having first identified the musculo-spiral groove, proceed to map out the areas of attachment of the humeral heads of the triceps as they are exhibited in the dissected part.

The *outer head* of the triceps arises from the outer and posterior aspect of the shaft of the humerus, above the level of the musculo-spiral groove. It takes origin, by short tendinous fibres, along a line which descends vertically from the insertion of the teres minor above to the upper border of the musculo-spiral groove below. But it also derives fibres from a strong aponeurotic bridge or arch, which is thrown over the groove, so as to give protection to the superior profunda artery and the musculo-spiral nerve. The strength and position of this arch can be tested by thrusting the handle of the knife downwards and outwards in the musculo-spiral groove, and along the course of the nerve and artery under the external head of the triceps. By its lower end the arch is connected with the external intermuscular septum.

The *inner head* of the triceps is placed below the musculo-spiral groove. It sends upwards, on the posterior

aspect of the humerus, and along the inner margin of the groove, a narrow pointed fleshy slip, which obtains origin from the bone as high as the insertion of the teres major muscle. Below, it widens out and arises by short fibres from the entire breadth of the posterior surface of the humerus. It also springs from the posterior surface of the internal intermuscular septum, and from the lower part of the corresponding surface of the external intermuscular septum. The inner head of the triceps, therefore, has very much the same origin from the back of the bone that the brachialis anticus has from the front of the bone.

The dissector should now study the *common tendon of insertion* of the triceps. The long and the outer heads end in a broad, flat tendon, which is inserted into the back part of the upper surface of the olecranon process, and at the same time gives off, on the outer side, a strong expansion to the fascia of the forearm as it covers the anconeus muscle. The short fleshy fibres of the inner head are, for the most part, inserted into the deep surface of the common tendon, but a considerable number find direct attachment to the olecranon, whilst a few of the deepest fibres are inserted into the loose posterior part of the capsule of the elbow-joint. These latter fibres have been described as a separate muscle under the name of *sub-anconeus*.*

The Musculo-spiral Nerve.—In order that this nerve may be fully exposed, the external head of the triceps must be divided. Thrust the handle of a knife along the musculo-spiral groove, and under the muscle. This will

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* The common tendon is spread out on the superficial surface of the outer head, but it is chiefly placed upon the deep surface of the long head, and it is into this latter portion of it that the fibres of the internal head are inserted. The student can readily satisfy himself on this point by slitting the muscle in a downward direction, in the line between the outer and long heads.

give the direction in which the outer head of the triceps should be severed. Beyond cleaning the nerve and its branches, and the superior profunda artery, as they lie in the groove, no further dissection is necessary.

The *musculo-spiral nerve* is the direct continuation of the posterior cord of the brachial plexus after it has furnished in the axilla the three subscapular and the circumflex nerves. In the first instance, the musculo-spiral proceeds downwards behind the lower part of the axillary artery and the upper part of the brachial artery. It soon leaves the front of the arm, however, and, inclining backwards with the superior profunda artery, enters the interval between the long and the inner heads of the triceps, and reaches the musculo-spiral groove. In this it is conducted round the back of the shaft of the humerus, under cover of the outer head of the triceps, and on the outer side of the limb it pierces the external intermuscular septum and appears in the anterior compartment of the arm. Here it has already been studied. It lies deeply in the interval between the brachialis anticus on the inside, and the supinator longus and extensor carpi radialis longior on the outside. It ends in front of the external condyle of the humerus by dividing into two terminal branches, viz. the radial and the posterior interosseous. The musculo-spiral nerve presents therefore very different relations as it is traced from its origin to its termination: (1) between the subscapularis, latissimus dorsi, teres major, and long head of the triceps which support it behind, and the axillary and brachial arteries which are placed in front of it; (2) between the long and inner heads of the triceps; (3) in the musculo-spiral groove between the bone and the outer head of the triceps; (4) in the interval between brachialis anticus on the inside, and supinator longus and extensor carpi radialis longior on the outside.

The branches which proceed from the musculo-spiral nerve are partly *muscular* and partly *cutaneous*.

The *cutaneous branches* are three in number, and have

already been traced. They are—(1) the *internal cutaneous*, which, as a rule, arises within the axilla, in common with the branch which supplies the inner head of the triceps; (2) the *upper external cutaneous;* and (3) the *lower external cutaneous*, which come off on the outer side of the arm close to the outer margin of the external intermuscular septum (p. 76).

The *muscular branches* go to the three heads of the triceps, to the anconeus, to the brachialis anticus, to the supinator longus, and to the extensor carpi radialis longior. The branches to the three last muscles spring from the main trunk after it has pierced the external intermuscular septum.

The branch to the inner head of the triceps, which arises in common with the internal cutaneous, is termed the *ulnar collateral nerve*. It is a long slender filament, which runs downwards to supply the lower fibres of the inner head of the triceps, and it receives this name from the close manner in which it is applied to the ulnar nerve in the lower part of its course.

The *branch to the anconeus* is also a long slender twig, which enters the substance of the triceps, and appears at first sight to terminate there, but, if traced downwards, it will be found to end in the anconeus.

Superior Profunda Artery.—This artery has been already observed to take origin from the brachial trunk, immediately below the lower margin of the teres major muscle. It accompanies the musculo-spiral nerve, and its relations to the three heads of the triceps and the musculo-spiral groove of the humerus are exactly the same as those of the nerve (p. 80). When it reaches the external intermuscular septum, at the other side of the arm, it ends by dividing into two terminal branches—an anterior and a posterior. The *anterior* and smaller branch accompanies the musculo-spiral nerve through the septum, and follows it downwards to the anterior aspect of the external

condyle of the humerus, where it anastomoses with the radial recurrent artery. The *posterior* larger branch proceeds downwards on the posterior surface of the external intermuscular septum, and anastomoses on the back of the external condyle of the humerus with the posterior interosseous recurrent artery.

The branches which proceed from the superior profunda artery are chiefly distributed to the three heads of the triceps muscle. One twig runs upwards between the long and outer heads of the muscle, and anastomoses with the posterior circumflex artery. In this way, therefore, a link is established between the axillary and brachial systems of branches.

Dissection.—The ulnar nerve, with the inferior profunda artery, and the slender ulnar collateral nerve, can now be advantageously followed, as they proceed downwards upon the posterior aspect of the internal intermuscular septum. They have a thin covering of the fibres of the internal head of the triceps. The posterior branch of the anastomotica magna, after it has pierced the internal septum, should also be dissected out. As a rule, a transverse branch passes between this vessel and the posterior terminal part of the superior profunda. It lies upon the back of the humerus, immediately above the elbow-joint, and can be exposed by dividing the triceps muscle a short distance above the olecranon. At the same time the fleshy fibres of the internal head of the triceps, which are inserted into the posterior ligament of the joint, and constitute the *subanconeus muscle*, should be examined. Lastly, raise the lower piece of the triceps from the joint, and look for a small bursa between the deep surface of the triceps tendon and the upper aspect of the olecranon.

SHOULDER-JOINT.

Before proceeding to the dissection of the forearm it is advisable to study the shoulder-joint, because if this is deferred much longer the ligaments are apt to become dry.

In no joint in the body is the movement so free, and so varied in its character, as in the shoulder-joint. This is rendered necessary by the many functions which are performed by the upper limb. Freedom of motion is provided for in two ways—(1) by the large size of the head of the humerus, in comparison with the small dimensions and shallow character of the glenoid fossa—the socket in which it moves; (2) by the great laxity of the ligamentous structures which connect the humerus with the scapula. These provisions for allowing an extensive range of movement at this articulation might, at first sight, lead one to doubt the security of the joint. Its strength certainly does not lie in the adaptation of the bony surfaces to one another, nor in the power of its ligaments. It lies—(1) in the intimate manner in which the scapular muscles are arranged around it; (2) in the overhanging coraco-acromial arch which forms, as it were, a secondary socket for the head of the humerus, and effectually prevents any displacement in an upward direction; and (3) in atmospheric pressure, which exercises a powerful influence in keeping the opposed surfaces in contact with each other.

From all points of view, except over a small area below, the loose, ligamentous capsule which envelopes the shoulder-joint is supported by muscles, the tendons of which are more or less intimately connected with it. *Above*, it is covered by the supraspinatus; *behind*, the infraspinatus and teres minor are applied to it; *in front* is the subscapularis. *Below*, the capsule is to a certain extent unsupported by muscles, and here it is prolonged downwards, in the form of a fold, in the ordinary easy dependent position of the limb. When, however, the arm is abducted, this fold is obliterated, and the head of the bone rests upon the inferior part of the capsule, which now receives partial support from two muscles which are stretched under it, viz. the long head of the triceps and the teres major. Still, this must be regarded as the weakest part of the joint, and consequently dislocation of the head of the humerus, downwards into the axilla through the inferior part of the capsule, is an occurrence of considerable frequency.

Dissection.—Begin by detaching the axillary vessels and brachial nerves from the coracoid process to which they

have been tied, and throw them downwards. Then proceed to remove the muscles. Divide the conjoined origin of the

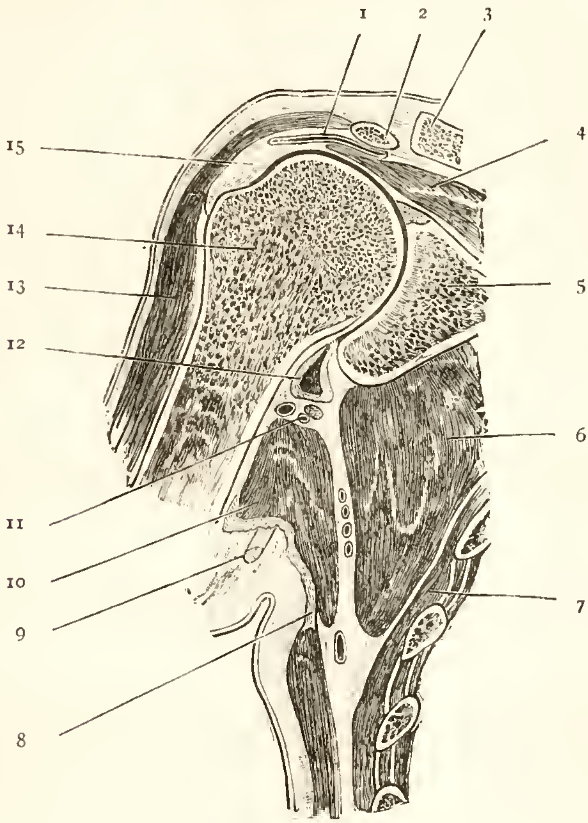

FIG. 20.

Coronal or Vertical Transverse Section through the Left Shoulder-joint. (Viewed from behind.)

1. Subacromial bursa.
2. Tip of outer end of clavicle.
3. Acromion process.
4. Supraspinatus.
5. Scapula.
6. Subscapularis.
7. Serratus magnus.
8. Latissimus dorsi.
9. Musculo-spiral nerve.
10. Teres major.
11. Posterior circumflex artery and circumflex nerve.
12. Fold of capsule of joint.
13. Deltoid.
14. Humerus.
15. Capsule of joint.

short head of the biceps and the coraco-brachialis close to the coracoid process, the teres major about its middle,

and the long head of the triceps about an inch or two below its origin, and turn them aside. Next deal with the muscles more immediately in relation to the joint, viz. the supraspinatus, the infraspinatus, the teres minor, and the subscapularis. These must be removed with great care and deliberation, because their tendons are closely connected with the subjacent ligamentous capsule. They are not incorporated with the capsule, however, although at first sight they appear to be so, and thus they can be dissected from it. In the case of the subscapularis a protrusion of the synovial membrane, forming a bursa, will be found near its upper border, close to the root of the coracoid process. The capsule of the shoulder-joint may now be cleaned, and its attachments defined.

The Ligaments in connection with the shoulder-joint are :—

1. The capsular ligament.
2. The coraco-humeral.
3. The gleno-humeral.
4. The glenoid.

The Capsular Ligament is a dense and strong ligamentous structure, which envelopes the shoulder-joint on all sides. It is attached to the scapula around the glenoid cavity, but only above is it directly fixed to the bone. Elsewhere it springs from the fibrous ring or glenoid ligament, which serves to deepen the articular cavity ; indeed, in its lower part, it appears to be continuous with the sharp border of the glenoid ligament. Externally it is fixed to the outer part of the anatomical neck of the humerus. The width of the capsule is not uniform throughout. It will be noticed to expand as it passes over the enclosed head of the humerus, and to contract as it reaches its scapular and humeral attachments. The great laxity of the capsule of the shoulder-joint will now be apparent. When the muscles are removed, and air is admitted into the joint, the bony surfaces fall away from each other—the

head of the humerus sinking downwards, when the part is held by the scapula, to the extent of an inch.

The capsule of the shoulder-joint is not complete upon all aspects. Its continuity is interrupted by two, and sometimes three, apertures. The largest of these is an opening of some size, which is placed upon its inner aspect, near the root of the coracoid process. Through this aperture an extensive protrusion of the synovial membrane takes place in the form of a synovial bursa, which, from its position under the upper part of the subscapularis muscle, receives the name of the *bursa subscapularis*. It is important to note the position and character of this opening, seeing that in some cases the head of the bone is driven through it in dislocation of the joint. The *second aperture* is smaller and more distinctly defined. It is placed between the two tuberosities of the humerus, at the upper part of the bicipital groove, and it is through this that the long tendinous head of the biceps gains admission to the interior of the capsule. The synovial membrane also protrudes from this opening, and lines the bicipital groove as low as the insertion of the pectoralis major. It is not often that the *third opening* will be seen. It is situated, when present, on the outer aspect of the capsule, and allows a pocket of synovial membrane to bulge out in the form of a bursa under the infraspinatus muscle.

At certain points the capsule of the shoulder-joint is specially thickened by the addition of fibres, which pass from the scapula to the humerus. Two of these thickened portions receive the names of the *coraco-humeral* and the *gleno-humeral* ligaments. A third is placed on the inferior aspect of the capsule, where it is not supported by muscles, viz. between the long head of the triceps and the subscapularis muscles. It is against this thickened portion of the capsule that the head of the humerus rests when the arm is abducted from the side, and it is sometimes spoken of as the *inferior accessory ligament*

The Coraco-humeral Ligament is placed upon the upper aspect of the joint. It is a broad band of great strength, which is thoroughly incorporated with the capsule. Above, it is fixed to the root of the coracoid process of the scapula, and it passes from this obliquely downwards and outwards, to gain attachment to the two tuberosities of the humerus. It forms a strong arch over the upper part of the bicipital groove, under which the tendon of the biceps passes.

The Gleno-humeral Ligament can only be seen when the joint is opened. The dissector should therefore, at this stage, divide the capsule circularly, in its lower half, mid-way between its two attachments, and, drawing the bones well apart from each other, look upwards into the cavity. The tendon of the biceps will be observed arching over the head of the humerus, to reach its insertion on the upper aspect of the glenoid cavity. Immediately internal to this, and parallel to it, will be noticed a ridge on the inner aspect of the capsule projecting into the joint. This slender band is the gleno-humeral ligament (of Mr. Flood). It is inserted into a faintly-marked pit on the anatomical neck of the humerus, close to the upper end of the bicipital groove.

Glenoid Ligament.—Complete the division of the capsular ligament, and drawing the tendon of the biceps through the intertubercular aperture in the capsule, separate the two bones from each other.

The *glenoid ligament* is the dense fibro-cartilaginous band which surrounds the margin of the glenoid cavity of the scapula, and is attached to its rim. It deepens, and at the same time serves to extend, the articular socket of the scapula. The intimate connection which it presents with the capsule of the joint can now be studied. Two tendons are also closely associated with it, viz. the long head of the triceps below, and the long head of the biceps above.

The Long Head of the Biceps is an important factor in the construction of the shoulder-joint. Entering the capsule through the opening between the two tuberosities of the humerus, it is prolonged over the head of the bone to the top of the glenoid cavity. Its insertion at this point should now be examined. It will be seen to divide into three portions, viz. a large intermediate part, which obtains direct attachment to the scapula, and two smaller lateral parts, which diverge from each other and blend with the glenoid ligament. The long head of the biceps, by its position within the capsule, and in the deep groove between the tuberosities of the humerus, serves to keep the head of the bone in place, and to steady it in the various movements at the shoulder-joint.

Synovial Membrane.—The synovial membrane lines the interior of the capsular ligament, and is reflected from it upon the anatomical neck of the humerus as far as the articular margin of the head of the bone. The bursal protrusion of the synovial membrane (*bursa subscapularis*) under the tendon of the subscapularis muscle has already been noticed. The tendon of the biceps, as it traverses the joint, is enveloped in a tubular sheath of the membrane, which bulges out through the opening of the capsule in the form of a bursa, which lines the bicipital groove, and receives the name of *bursa intertubercularis*.

The Articular Surfaces of the bones should now be examined. The smooth, glistening articular cartilage, which coats the head of the humerus, is thickest in the centre, and thins as it passes towards the edges. In the case of the glenoid cavity the reverse of this will be noticed. The cartilaginous coating is thinnest in the centre, and becomes thicker as it is traced towards the circumference.

Movements at the Shoulder-joint.—The shoulder is a ball and socket joint, and consequently movement in every direction is per-

mitted, viz.—(1) *flexion*, or forward movement; (2) *extension*, or backward movement (checked in its extent by the coraco-humeral ligament); (3) *abduction*, or outward movement (checked by the coraco-acromial arch); (4) *adduction*, or inward movement (limited by the coraco-humeral ligament). In addition to these different forms of angular movement, *rotation* to the extent of a quarter of a circle and *circumduction* are permitted.

The **muscles** chiefly concerned in producing these movements are—*flexion*, the pectoralis major and the anterior part of the deltoid; *extension*, latissimus dorsi, posterior part of the deltoid, and the teres major; *abduction*, the deltoid and supraspinatus; *adduction*, pectoralis major, coraco-brachialis, teres major, and latissimus dorsi; *rotation inwards*, subscapularis, pectoralis major, latissimus dorsi, teres major; *rotation outwards*, supraspinatus, infraspinatus, and teres minor: *circumduction* is produced by the action of different combinations of these muscles.

FOREARM.

The skin has already been removed from the front and back of the forearm. It should now be raised from the dorsum of the hand by making incisions along the radial and ulnar borders. This is done in order that the superficial structures in this region may be examined in connection with those of the forearm.

Superficial Veins.—On the dorsum of the hand a plexus of superficial veins will be seen. In defining this, care must be taken of the fine cutaneous twigs from the radial nerve and the dorsal branch of the ulnar nerve. From the outer part of the venous plexus the large radial vein takes origin, whilst from its inner part springs the posterior ulnar vein. Both of these vessels have already been traced along the forearm to their terminations. While still upon the dorsum of the hand each communicates with the deep veins in the palm of the hand.

Cutaneous Nerves.—Several cutaneous nerves have already been traced to the integument of the forearm,

viz. the anterior and posterior branches of the internal cutaneous nerve to the inner aspect, and the cutaneous part of the musculo-cutaneous and lower external cutaneous branch of the musculo-spiral upon the outer aspect of the limb. Some additional twigs make their appearance by piercing the fascia in the lower third of the forearm. These are:

1. The palmar cutaneous branch of the ulnar nerve, ...
2. The palmar cutaneous branch of the median nerve, ...
3. The palmar cutaneous branch of the radial nerve, ...

on the front aspect.

1. The dorsal branch of the ulnar nerve,
2. The radial nerve, ...

on the dorsal aspect.

The Palmar Cutaneous Branches are small twigs which supply the skin of the palm. The *twig from the ulnar nerve* takes origin about the middle of the forearm, but it does not at once pierce the deep fascia. It proceeds downwards on the ulnar artery, and becomes superficial immediately above the annular ligament, and close to the outer side of the insertion of the flexor carpi ulnaris tendon into the pisiform bone. It is here, therefore, that it must be sought.

The *palmar cutaneous branch of the median nerve* appears through the deep fascia in the middle of the lower part of the forearm, immediately above the wrist, and is continued downwards into the palm.

The *palmar branch of the radial nerve* runs close to the outer border of the lower part of the forearm. It does not spring from the trunk of the radial nerve, but from that branch of it which goes to the outer margin of the thumb. It is joined by a twig from the musculo-cutaneous nerve, and proceeds downwards in front of the tendon of the

extensor ossis metacarpi pollicis, to end in the skin covering the ball of the thumb.

Dorsal Cutaneous Branches.—In tracing the nerves which appear on the back of the limb, it will be necessary to remove the skin from the dorsal aspect of the thumb and fingers. The great flap of skin which is still attached at the roots of the fingers may be detached, and an incision can then be made along the middle of the dorsal aspect of each digit. The skin should be carefully raised from each digit in two flaps and thrown outwards and inwards.

The *dorsal branch of the ulnar nerve* winds round the inner margin of the wrist to reach the dorsum of the hand. It will be found immediately below the prominence formed by the lower end of the ulna, and it at once divides into three main terminal branches. Of these, *the innermost* runs along the ulnar margin of the dorsum of the hand, and is continued onwards along the inner margin of the little finger. The *second branch* proceeds towards the cleft between the little finger and the ring finger, and divides into two twigs which supply the contiguous sides of these digits. The *third branch* joins a twig from the radial, and the nerve thus formed runs towards the interval between the ring finger and the middle finger, and divides to supply their adjacent margins. Each of these three main branches gives several minute filaments to the integument on the dorsum of the hand.

The *radial nerve* will be found winding round the outer margin of the forearm, about two inches above the extremity of the styloid process of the radius. It at once gives off a long twig which proceeds along the radial margin of the hand and thumb. A little further on the radial nerve breaks up into four terminal branches, which are distributed as follows: the *first* supplies the ulnar side of the thumb; the *second* goes to the radial side of the index finger; the *third* divides to supply the adjacent sides of the index and middle fingers; whilst the *fourth* joins

with a twig from the dorsal branch of the ulnar (as already described) to supply the contiguous margins of the middle and ring fingers.

It should be noted that, except in the cases of the thumb and little fingers, the dorsal collateral nerves do not reach the extremities of the digits. The skin on the back of the lower part of the digits is supplied by twigs, which proceed backwards from the palmar collateral nerves. As already stated, it is from the branch of the radial, which goes to the outer side of the thumb, that the *radial palmar cutaneous nerve* arises.

Numerous fine filaments are given to the skin on the dorsum of the hand, and, as Dr. Brooks has shown, a certain amount of crossing of the adjacent ulnar and radial twigs takes place in this locality; in other words, twigs from the one nerve invade the territory which is occupied by the other nerve.

The Deep Fascia, which envelopes the forearm, should now be cleaned by removing the subcutaneous adipose tissue. It is an aponeurosis of great strength and density. More particularly is this the case on the posterior aspect of the limb, and also in the lower third of the forearm, where the fleshy bellies of the subjacent muscles give place to the tendons. In its upper part it receives an accession of fibres from the tendon of the biceps in the form of the bicipital or semilunar fascia. Some fibres are also given to it by the tendon of the triceps. Near the elbow it serves as a surface of origin for the numerous muscles which spring from the condyles of the humerus, and from its deep aspect dense septa pass between the fleshy bellies. These partitions are indicated on the surface by a series of white lines. At the wrist it becomes continuous in front with the *anterior annular ligament*, whilst behind it forms an obliquely placed, thickened band, the *posterior annular ligament*. On the dorsum of the hand the deep fascia is very thin.

FRONT AND INNER BORDER OF THE FOREARM.

In this dissection the following structures will be brought under the notice of the student:—

1. The radial and ulnar arteries and their branches.
2. The median and ulnar nerves and their branches.
3. The posterior interosseous and the radial nerves.
4. The group of pronator and flexor muscles.

Dissection.—With the exception of the palmar cutaneous nerves, the superficial veins and nerves on the front of the forearm may now be turned aside. The deep fascia should also be removed, and on dissecting it inwards round the ulnar border of the forearm it will be found to be firmly attached to the posterior border of the ulna. Near the elbow, as already stated, it gives origin by its deep surface to the group of muscles which spring from the internal condyle of the humerus. Where this is the case it should be left *in situ*. Attempts to dissect it off will only result in laceration of the surface of the subjacent fleshy bellies. The radial artery should be followed out before the muscles are much disturbed, and at the same time the various muscles which lie upon the anterior surface of the radius, and upon which the vessel rests, should be cleaned.

The Radial Artery is the smaller of the two terminal branches of the brachial artery, but the direction which it takes gives it the appearance of being the continuation of the parent trunk into the forearm. It takes origin in the anticubital fossa opposite the neck of the radius, and it proceeds downwards along the outer side of the front of the limb until it reaches the lower end of the bone. Here it turns round the outer aspect of the wrist and leaves the present dissection. At first it lies between the pronator radii teres and the supinator longus, and is overlapped to

some extent on the outer side by the fleshy belly of the latter muscle (Fig. 21). Lower down it is placed between the supinator longus on the outside, and the flexor carpi radialis upon the inner side, and as the tendons of these muscles become more pronounced it assumes a superficial position, and is merely covered by the integument and fasciæ. Throughout its whole length it is closely accompanied by the *venae comites*, and the radial nerve lies along its outer side in the middle third of the forearm. Above this, the nerve is separated from the vessel by a slight interval, whilst below, the nerve leaves the artery by turning round the outer margin of the forearm under cover of the supinator longus.

Posteriorly the radial artery is supported by the muscles which clothe and find attachment to the front of the radius. At its origin it rests upon the tendon of the biceps; next it lies in front of the supinator brevis, with some adipose tissue intervening; from this downwards it is in contact with the pronator radii teres, the thin radial head of the flexor sublimis, the flexor longus pollicis, the pronator quadratus, and lastly, the lower end of the radius.

The radial artery is usually selected for the determination of the *pulse*. By placing the tips of the fingers upon the lower part of the forearm, in the interval between the tendons of the supinator longus and flexor carpi radialis, the pulsations of the vessel in the living person can readily be felt.

In the forearm the radial artery gives off the following branches, viz.:—

1. The radial recurrent.
2. The superficialis volae.
3. The anterior radial carpal.
4. Muscular.

The *muscular branches* are very numerous, and proceed from the radial artery at irregular points throughout its whole course in the forearm.

The *radial recurrent artery* is a branch of some size. It takes origin close to the commencement of the radial artery, and in the first instance runs outwards between the supinator longus and the supinator brevis. Here it comes into relation with branches coming from the musculo-spiral nerve, and gives off several twigs for the supply of the muscles arising from the external condyle of the humerus. Somewhat reduced in size, it now turns upwards in the interval between the supinator longus and brachialis anticus, and ends in front of the external condyle of the humerus by an astomosing with the anterior terminal branch of the superior profunda artery.

The *superficialis volae artery* is a small, variable branch, which arises a short distance above the wrist, and runs downwards to end in the muscles of the ball of the thumb. Sometimes, however, it attains a larger size and a special importance, from its being continued into the palm to complete the superficial palmar arch on the outer side.

The *anterior radial carpal* is a minute twig which springs from the radial at the lower border of the pronator quadratus muscle. It runs inwards under cover of the flexor tendons, and joins the corresponding branch of the ulnar artery to form the *anterior carpal arch*.

Radial and Posterior Interosseous Nerves.—The musculo-spiral nerve has already been observed to end in front of the elbow, under cover of the supinator longus muscle, in its two terminal branches, the radial and the posterior interosseous. These nerves may now be studied in so far as they lie in the front of the forearm. The *posterior interosseous nerve* soon disappears from view by passing backwards through the fibres of the supinator brevis muscle.

The *radial nerve* proceeds downwards under cover of the fleshy belly of the supinator longus. In the middle third of the forearm it lies along the outer side of the radial artery, and then leaves it by winding round the outer

margin of the limb, under cover of the tendon of the supinator longus. It has been traced in its further course (p. 100). The radial is a purely cutaneous nerve, and gives off no branches until it gains the dorsal aspect of the lower end of the forearm.

Muscles.—The muscles on the front and inner border of the forearm are arranged in a superficial and a deep

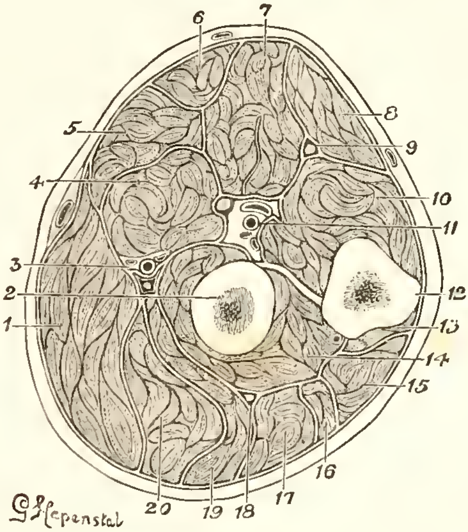

FIG. 21.

Transverse Section through the Upper Third of the Forearm.

1. Supinator longus.
2. Radius.
3. Radial vessels.
4. Pronator radii teres.
5. Flexor carpi radialis.
6. Palmaris longus.
7. Flexor sublimis.
8. Flexor carpi ulnaris.
9. Ulnar nerve.
10. Flexor profundus.
11. Ulnar vessels and median nerve.
12. Ulna.
13. Small portion of anconeus.
14. Supinator brevis.
15. Extensor carpi ulnaris.
16. Extensor minimi digiti.
17. Extensor communis.
18. Posterior interosseous nerve.
19. Extensor carpi radialis brevior.
20. Extensor carpi radialis longior.

group. They comprise the flexors of the wrist and fingers, and also the pronators. In the *superficial group* we find

the pronator radii teres, the flexor carpi radialis, the palmaris longus, the flexor sublimis digitorum, and the flexor carpi ulnaris, in that order from without inwards. The fleshy belly of the flexor sublimis only partially comes to the surface; the chief bulk of it is placed upon a deeper plane than the others. The *deep group* is composed of three muscles, placed in contact with the bones and interosseous membrane of the forearm, viz. the flexor profundus digitorum in relation to the ulna, the flexor longus pollicis in relation to the radius, and the pronator quadratus closely applied to the lower ends of both bones.

The superficial group of muscles should now be dissected. The supinator longus, which lies along the outer side of the forearm, may be cleaned at the same time. In the lower part of the forearm the dissector will observe that the flexor tendons are enveloped by a loose bursal sac as they pass into the palm, under cover of the anterior annular ligament. A good view of this may be obtained by pulling the tendons upwards. If possible the sac should be retained uninjured, in order that its full extent may be studied when the palm of the hand is opened up. At this stage it is also well to define the anterior annular ligament which bridges across the front of the carpus. The tendon of the palmaris longus passes in front of it, whilst close to the pisiform bone the ulnar artery and nerve are placed upon its anterior surface, and give the dissector the key to its depth. This vessel, with its accompanying nerve, are bound down to the ligament by a slip of fascia, which passes over them from the pisiform bone, and which the student is very apt to mistake for the annular ligament itself. This should not be disturbed in the meantime.

Common Origin of the Superficial Muscles.—The five muscles which constitute the superficial group are very closely associated with each other at the elbow—indeed they may be said to arise by a common origin from the

front of the internal condyle of the humerus. In addition to this they all derive fibres from the investing deep fascia of the limb near the elbow, and the strong fibrous septa which pass into the forearm from the deep surface of this in the intervals between them. The pronator radii teres, the flexor sublimis, and the flexor carpi ulnaris, have likewise additional heads of origin.

The Pronator Radii Teres crosses obliquely the upper half of the front of the forearm. It arises by two heads, viz. a humeral and a coronoid. The *humeral head* constitutes the chief bulk of the muscle, and it springs from the upper part of the internal condyle of the humerus, and also slightly by fleshy fibres from the lower part of the internal supracondyloid ridge. The fascia covering it and the fibrous septum on its inner side also contribute fibres. The *coronoid head* is placed deeply, and it may be recognised from the fact that it intervenes between the median nerve and the ulnar artery. To bring it into view the superficial humeral head must be drawn well inwards. The coronoid head is very variable in size. As a rule it is a small fleshy slip, but sometimes it is chiefly fibrous. It arises from the inner aspect of the coronoid process of the ulna, and soon joins the deep surface of the humeral head. The muscle thus formed is carried obliquely downwards and outwards, and ends in a tendon which gains insertion into a rough impression upon the middle of the outer surface of the radius. This attachment is placed on the summit of the chief curve of the radius, an arrangement which enables the muscle to exercise its pronating action at a great advantage. Close to its insertion the pronator radii teres is crossed by the radial artery and is covered by the supinator longus muscle.

The Flexor Carpi Radialis arises from the common tendon, from the fascia of the forearm and the fibrous septa which intervene between it and the adjacent

muscles. Its fleshy belly gives place a short distance below the middle of the forearm to a long flattened tendon, which at the wrist traverses the groove on the front of the trapezium in a special compartment of the anterior annular ligament. It is inserted into the base of the metacarpal bone of the index, and slightly also into the base of the metacarpal bone of the middle finger. Its relations to the annular ligament, and also its attachment to the metacarpus, will be exposed and studied at a later stage of the dissection.

The Palmaris Longus is a long slender muscle, which is not always present. It springs from the common origin, the aponeurotic investment of the forearm and the fibrous septa on either side of it. Its tendon pierces the deep fascia immediately above the wrist, and then proceeds downwards in front of the annular ligament to join the strong palmar fascia of the hand. Very frequently it gives a slip to the abductor pollicis.

The Flexor Carpi Ulnaris arises by two heads. One of these is incorporated with the common origin from the humeral condyle; the other springs from the inner aspect of the olecranon process of the ulna, and likewise from the posterior border of the same bone in its upper two thirds, by an aponeurotic attachment. Fibres are also derived from the investing fascia and the intermuscular septum on its outer side. The two heads of origin of the flexor carpi ulnaris bridge across the interval between the internal condyle of the humerus and the olecranon process, and between them the ulnar nerve is prolonged downwards into the forearm. The tendon appears upon the anterior border of the muscle, and is inserted into the pisiform bone.

The Flexor Sublimis Digitorum receives this name from its being placed upon the superficial aspect of the flexor

profundus. For the most part it lies deeper than the other superficial muscles. It is a powerful muscle which arises from the internal condyle of the humerus by the common tendon, but it also takes origin from the internal lateral ligament of the elbow-joint, from the inner margin of the coronoid process of the ulna, the front of the radius, and the fascial intermuscular septa in relation to it. The radial head of origin is a thin fleshy stratum which is attached to the oblique line of the radius and the anterior border of that bone for a variable distance below the insertion of the pronator radii teres. Four tendons issue from the fleshy mass. These go to the four inner digits, and enter the palm by passing under cover of the anterior annular ligament. Their insertions will be seen later on, but in the meantime note that at the wrist and for a short distance above it they are enveloped by the bursal sac previously mentioned, and also that as they pass behind the annular ligament they lie in pairs—the tendons to the ring and middle fingers being placed in front of those for the index and little fingers.

Ulnar Artery.—The ulnar artery and at the same time the ulnar and median nerves should be followed in their course through the forearm. The artery in the upper part of its course lies very deeply, but its relations can be fully studied and its branches traced by simply slitting up the intermuscular septum between the flexor sublimis digitorum and the flexor carpi ulnaris.

The *ulnar artery* is the larger of the two terminal branches of the brachial trunk, and it takes origin in the anticubital fossa opposite the neck of the radius. At first it inclines obliquely downwards and inwards, and having gained the front of the ulnar side of the forearm, it proceeds vertically downwards to the wrist. Here it enters the palm by passing in front of the anterior annular ligament. In the upper oblique portion of its course the vessel is deeply placed, and is crossed by both heads of

the pronator radii teres, the flexor carpi radialis, the palmaris longus, and the flexor sublimis digitorum. In its lower vertical part it is overlapped on the inner side by the flexor carpi ulnaris, but a short distance above the wrist it becomes superficial, and lies in the interval between the tendon of the flexor carpi ulnaris on the inside and the tendons of the flexor sublimis on the outside. On the annular ligament it is placed close to the outer side of the pisiform bone, and is covered by a strong slip of fascia, which passes from that bone to the front of the ligament. Throughout its entire course it is accompanied by two *venae comites*. It likewise presents relationships with the median and ulnar nerves. The *median nerve*, which lies upon its inner side at its origin, soon crosses it, but as it does so it is separated from the artery by the deep head of the pronator radii teres. The *ulnar nerve* in the upper third of the forearm is separated from the vessel by a wide interval, but in the lower two thirds of the forearm it closely accompanies the artery, and lies on its inner side.

In the anticubital fossa the ulnar artery rests upon the brachialis anticus; beyond this it is in contact behind with the flexor profundus digitorum; whilst at the wrist, as we have noted, the artery lies upon the anterior surface of the anterior annular ligament.

In the forearm the ulnar artery gives off the following branches :—

1. Anterior ulnar recurrent.
2. Posterior ulnar recurrent.
3. Common interosseous.
4. Anterior ulnar carpal.
5. Posterior ulnar carpal.
6. Muscular twigs.

The *muscular twigs* are of small size, and come off at variable points for the supply of the neighbouring muscles.

The *anterior ulnar recurrent artery* is the smaller of the two recurrent branches. It runs upwards in front of the

internal condyle of the humerus, in the interval between the pronator radii teres and the brachialis anticus muscles, and it anastomoses with the anterior terminal branch of the anastomotica magna.

The *posterior ulnar recurrent* passes inwards under cover of the flexor sublimis digitorum, and then turns upwards between the two heads of origin of the flexor carpi ulnaris to gain the interval between the internal condyle of the humerus and the olecranon process. Here it comes into contact with the ulnar nerve, and anastomoses with the posterior terminal branch of the anastomotica magna and with the inferior profunda artery.

It is not uncommon to find the two recurrent arteries arising from the ulnar trunk by a short common stem.

The *common interosseous artery* is a short, wide trunk, which takes origin immediately below the recurrent branches, about an inch or so below the commencement of the ulnar artery. It proceeds backwards, and at the upper margin of the interosseous membrane it divides into two terminal branches, viz. the *anterior* and the *posterior interosseous arteries*.

The *ulnar carpal branches* are two small arteries, which partially encircle the wrist. The *anterior ulnar carpal* runs inwards, under cover of the tendons of the flexor profundus digitorum, and anastomoses with the anterior radial carpal artery. From the arch thus formed small twigs are given to the front aspect of the carpal bones and joints. The *posterior ulnar carpal artery* gains the dorsal aspect of the carpus by winding round the ulnar margin of the limb immediately above the pisiform bone, and under cover of the tendon of the flexor carpi ulnaris.

Ulnar Nerve.—The ulnar nerve, which was traced in the dissection of the arm as far as the interval between the olecranon and internal condyle of the humerus, enters the forearm between the two heads of the flexor carpi

ulnaris. It proceeds downwards upon the flexor profundus digitorum, and under cover of the flexor carpi ulnaris along the front of the ulnar side of the forearm. Close to the wrist it becomes superficial upon the outer side of the tendon of the flexor carpi ulnaris, and it reaches the palm by passing in front of the anterior annular ligament. In the upper third of the forearm the ulnar nerve is separated from the ulnar artery by an interval, but below this it is closely applied to the inner side of the vessel.

In the forearm the ulnar nerve gives off:—

1. Articular branches to the elbow joint.
2. Muscular branches, . { to the flexor carpi ulnaris and the inner part of the flexor profundus.
3. Cutaneous branches, { palmar cutaneous. dorsal cutaneous.

The *articular filaments* come from the ulnar nerve as it lies in the interval between the olecranon and internal condyle of the humerus.

The *muscular branches* are given off high up in the forearm, and supply the flexor carpi ulnaris and the inner part of the flexor profundus digitorum.

The *ulnar palmar cutaneous branch* is a minute twig, which has already been seen piercing the fascia of the forearm immediately above the annular ligament. It arises about the middle of the forearm and proceeds downwards upon the ulnar artery, to the coats of which it gives fine filaments.

The *ulnar dorsal cutaneous branch* is a nerve of some size which springs from the ulnar trunk about two and a-half or three inches above the wrist. It winds round the ulnar margin of the forearm under cover of the flexor carpi ulnaris, and reaches the dorsum of the hand immediately below the prominence formed by the lower end of the ulna. From this point onwards it has been traced in the superficial dissection (p. 100).

The Median Nerve, as its name implies, passes down the middle of the forearm, and to obtain an unbroken view of it, it is necessary to reflect the condylar head of the pronator radii teres and the radial head of the flexor sublimis digitorum.

In the upper part of the forearm the median nerve lies in the anticubital fossa upon the inner side of the ulnar artery. It leaves this space by passing between the two heads of the pronator radii teres, and as it does so it crosses the ulnar artery, but is separated from the vessel by the coronoid or deep head of the muscle. From this point the median nerve is carried downwards between the flexor sublimis and the flexor profundus digitorum. Near the wrist it becomes superficial, and lies in the interval between the tendons of the flexor sublimis on the inside, and the flexor carpi radialis on the outer side. Finally it leaves the forearm by passing behind the anterior annular ligament of the wrist. A small artery, the *median* branch of the anterior interosseous, accompanies the median nerve. Sometimes this vessel attains a considerable size.

As the median nerve enters the forearm it gives off numerous branches for the supply of muscles, and near the wrist it supplies the *median palmar cutaneous nerve*, which has already been dissected.

The *muscular branches* supply the pronator radii teres, the flexor carpi radialis, the palmaris longus, and the flexor sublimis digitorum—all the muscles of the superficial group therefore, with the single exception of the flexor carpi ulnaris.

It likewise supplies a long slender twig—*the anterior interosseous*—which goes to the deep muscles on the front of the forearm.

Deep Dissection.—The connections of the deep muscles must now be studied, and at the same time the anterior interosseous artery and nerve must be followed. The flexor profundus is the large muscle which clothes the

anterior and inner aspects of the ulna; the flexor longus pollicis is placed upon the anterior surface of the radius; while the pronator quadratus is a quadrate fleshy layer closely applied to both bones immediately above the wrist. The artery and nerve proceed downwards in the interval between the flexor profundus and flexor longus pollicis.

The Flexor Profundus Digitorum springs from the anterior and internal surfaces of the ulna in its upper three fourths. It likewise derives fibres from the anterior surface of the interosseous membrane and the aponeurosis, by which the flexor carpi ulnaris takes origin from the posterior border of the ulna. The fleshy mass gives place to four tendons for the four inner digits, but only one of these—that for the forefinger—becomes separate and distinct in the forearm. They proceed downwards behind the anterior annular ligament into the palm.

The Flexor Longus Pollicis arises from the anterior surface of the radius, from the oblique line above to the upper border of the pronator quadratus below. It also takes origin from the adjacent part of the anterior surface of the interosseous membrane. A rounded tendon issues from the fleshy belly, and proceeds into the palm, under cover of the anterior annular ligament.

In many cases the flexor longus pollicis will be observed to have an additional slender head of origin, from the inner side of the coronoid process of the ulna, or the internal condyle of the humerus.

The Pronator Quadratus takes origin from the anterior surface of the ulna in its lower fourth, and is inserted into the front aspect of the lower end of the radius.

The Anterior Interosseous Artery has been seen to arise from the common interosseous. It runs downwards

upon the front of the interosseous membrane, in the interval between the flexor longus pollicis and the flexor profundus digitorum. At the upper border of the pronator quadratus it pierces the interosseous membrane, and gains the posterior aspect of the limb.

It supplies *muscular twigs* to the three deep muscles with which it is in contact. In addition to these it gives off the following branches :—

1. Median.
2. Medullary.
3. Anterior communicating.

The *median artery* is a long, delicate vessel, which accompanies the median nerve. The *medullary arteries* are two in number—one for the radius, the other for the ulna. They enter the nutrient foramina of these bones, and are carried upwards into the interior. The *anterior communicating* is a slender artery, which runs downwards, behind the pronator quadratus, to join the anterior carpal arch.

The Anterior Interosseous Nerve is a branch of the median, and accompanies the artery of the same name. It does not follow it, however, through the interosseous membrane, but is distributed entirely upon the front of the limb. It is the nerve of supply for the flexor longus pollicis, the outer part of the flexor profundus digitorum,* and the pronator quadratus, whilst its terminal filament proceeds downwards, behind the last-named muscle, to help in the supply of the carpal joints.

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* The flexor profundus digitorum is therefore supplied by two nerves, viz. the ulnar and the median. The precise range of supply by each of these nerves is somewhat variable. In four cases Dr. Brooks found the division of the muscle which belongs to the index finger supplied by the median; the part belonging to the little finger supplied by the ulnar; whilst the portions belonging to the middle and ring digits received nerve filaments from both nerves.

WRIST AND PALM.

In this dissection we meet with the following structures:—

1. Palmaris brevis and the palmar cutaneous nerves.
2. Palmar fascia.
3. Superficial palmar arch and its branches.
4. Median and ulnar nerves and their branches.
5. Anterior annular ligament, the flexor tendons, and the flexor sheaths.
6. Lumbrical muscles.
7. Short muscles of the thumb and little finger.
8. Deep palmar arch and its branches.
9. Arteria princeps pollicis and arteria radialis indicis.

Surface Anatomy.—In the centre of the palm the depression, known as the 'hollow of the hand,' may be remarked. Along the ulnar border of the palm this is bounded by a rounded elevation, called the *hypothenar eminence*. This is produced by the subjacent short, intrinsic muscles of the little finger. The *thenar eminence*, or ball of the thumb, formed by the short muscles of that digit, is the marked projection which limits the palmar hollow above and on the outer side; whilst the transverse elevation above the roots of the fingers, which corresponds to the metacarpo-phalangeal articulations, constitutes the lower boundary of the central palmar depression. Two very pronounced bony projections on the front of the wrist cannot fail to attract attention. The more prominent of the two is situated at the upper extremity of the thenar eminence, and is formed by the tubercle of the scaphoid bone and the vertical ridge on the front of the trapezium; the other is placed at the upper end of the hypothenar eminence, and is somewhat obscured by the soft parts attached to it. It is the pisiform bone, and when taken firmly between the finger and thumb a slight degree of gliding movement can

be communicated to it. Traversing the thick integument of the palm, three strongly-marked furrows are apparent. One of these begins at the elevation formed by the scaphoid and trapezium, and curves downwards and out-

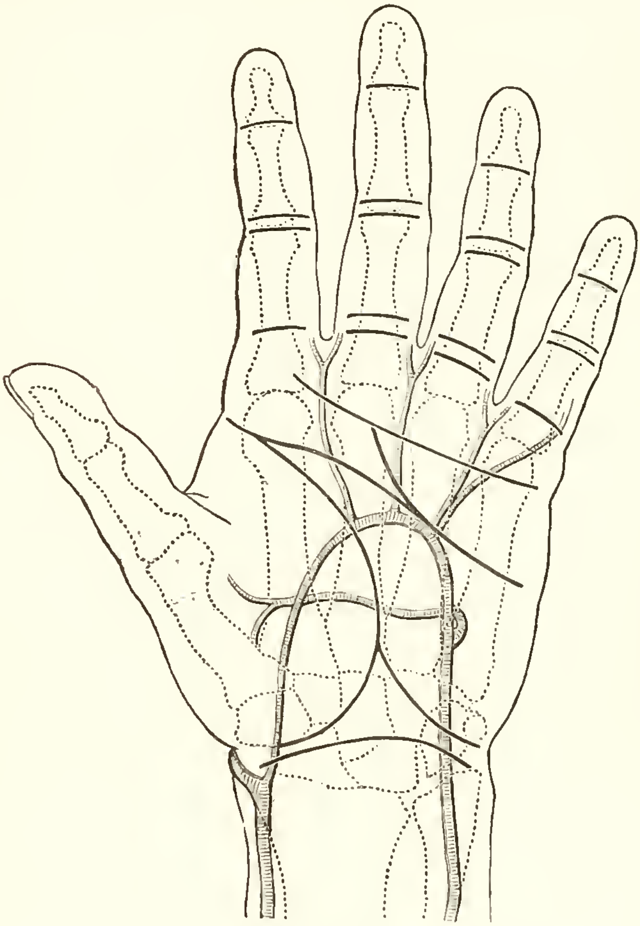

FIG. 22. (From Treves.)

wards around the base of the thenar eminence to the outer margin of the hand. A second crosses the palm transversely. Commencing at the middle of the outer border of the hand, where the first furrow ends, it runs

inwards, but, as a general rule, it fades away as it reaches the hypothenar eminence. The third furrow begins near the cleft between the index and middle fingers, and proceeds inwards with a gentle curve across the hypothenar eminence to the inner margin of the hand. The transverse cutaneous furrows at the roots of the fingers, and on the palmar aspects of the interphalangeal joints, should also be noticed, and it should always be remembered that, except in the case of the proximal interphalangeal joints, these do not correspond accurately with the subjacent articulations. The furrows at the roots of the fingers are placed at least one inch below the metacarpo-phalangeal joints, whilst the distal interphalangeal furrows lie slightly lower than the corresponding interphalangeal joints. The upper of the two furrows in front of each of the proximal interphalangeal joints is placed immediately over the articulation.

Reflection of Skin.—In the first instance the skin should only be raised from the palm. Two incisions are required. viz—(1) a vertical incision along the middle line of the palm; (2) a transverse cut across the roots of the fingers from the ulnar to the radial margin of the hand. The skin is tightly bound down to the subjacent deep fascia, and it must be raised with care. More especially is it necessary to proceed with caution at the roots of the fingers in order that some transverse fibres constituting a superficial cutaneous ligament may be preserved. In reflecting the inner flap of integument it is well not to lift it quite as far as the ulnar border of the hand, because it is into this portion of skin that the palmaris brevis is inserted.

Superficial Structures.—The *superficial fascia* over the central part of the palm is dense and thin. The fat is subdivided into small lobules by fibrous septa which bind the skin to the subjacent palmar fascia. Towards the

ulnar and radial margins of the hand the fat becomes softer, and the amount of fibrous tissue in its midst diminishes. In connection with the superficial fascia of the palm we have to study—(1) the palmaris brevis; (2) the superficial transverse ligament; and (3) the palmar cutaneous nerves.

The *palmaris brevis* is a small cutaneous muscle embedded in the superficial fascia which covers the upper part of the hypothenar eminence. If it has not already been exposed by the reflection of the skin, carry the knife transversely through the granular fat on the ulnar margin of the palm immediately below the anterior annular ligament. The fleshy bundles of the muscle will come into view. When these have been cleaned, the muscle will be seen to consist of a series of distinct fasciculi, which in its lower part are frequently separated from each other by intervals of varying width. It constitutes a thin fleshy layer, which covers an inch and a-half or more of the hypothenar eminence. Externally it takes origin from the anterior annular ligament and inner border of the central part of the palmar fascia, whilst internally its fasciculi are inserted into the skin over the ulnar margin of the hand.

The *palmar cutaneous nerves* are three in number, and they arise, as already noted, from the ulnar, median, and radial nerves. They should now be traced to their ultimate distribution in the palm of the hand.

The *transverse superficial ligament* is a band of fibres which extends across the palm at the roots of the fingers. It is intimately connected with the skin, and is enclosed within the folds of integument in the clefts between the fingers.

Dissection.—The palmaris brevis should be reflected by detaching its fasciculi from their origin, and turning them inwards. In raising the muscle care must be taken of the ulnar artery and nerve, which lie under

cover of it, and a little nerve-filament from the latter should be traced into its substance. The granular fat should next be removed from the palm, and the dense palmar fascia cleaned. Towards the roots of the fingers the digital vessels and nerves, together with the lumbrical muscles, appear in the intervals between the slips into which the palmar fascia divides. These should be defined, and it will be seen that they pass downwards under cover of the superficial transverse ligament. Having noted this point, remove the ligament. The digital arteries and nerves for the inner side of the little finger, and the outer side of the index, appear beyond the area of the central part of the deep fascia, higher up than the others, and are consequently liable to injury, unless it be remembered that they occupy this position.

Palmar Fascia.—The deep fascia of the palm is composed of three portions—a central and two lateral. The *lateral parts* are thin and weak, and are spread over the muscles which constitute the thenar and hypothenar eminences on the outer and inner margins of the palm. The *central portion* of the palmar fascia, on the other hand, is exceedingly strong and dense, and is spread out over the middle of the palm. It counteracts the effect of pressure in this region, and effectually protects the vessels, nerves, and tendons, over which it is stretched. Its strength differs considerably in different hands, and it is seen to best advantage in the horny hand of a labourer, or of a mechanic who has been in the habit of handling heavy implements. In shape it is triangular. Above, it is narrow and pointed, and at the wrist it is attached to the anterior annular ligament, and receives the insertion of the flattened tendon of the palmaris longus. As it approaches the heads of the metacarpal bones it expands, and finally divides into four slips, which separate slightly from each other, and pass to the roots of the four inner digits. It gives no slip to the thumb.

For the most part it is composed of longitudinal fibres, but, where it divides, a series of strong and very evident transverse fibres pass across it, in relation to its deep surface, and bind together its diverging slips.

In the three intervals between the digital slips of the palmar fascia, the digital arteries and nerves, together with the corresponding lumbrical muscles, make their appearance.

The connections of the four digital slips of the palmar fascia must be closely examined. Each lies in front of the two flexor tendons, proceeding to the finger with which it is connected, and each will be observed to divide into two portions, so as to form an arch under which these tendons pass. This arch is connected with the flexor sheaths, which bind the tendons to the front of the finger, and the two portions which form it are carried backwards, to obtain attachment to the transverse metacarpal ligament, which stretches transversely across the front of the heads of the metacarpal bones. These relations can only be satisfactorily made out by dividing the arch, and slitting the slip of fascia in an upward direction.

Fascial Compartments of the Palm.—Two weak septa proceed into the palm from the margins of the strong central portion of the palmar fascia. They join a layer of fascia, which is spread out over the interosseous muscles and the deep palmar arch, and they thus subdivide the palm into three fascial compartments, viz. a *central*, containing the flexor tendons, the lumbrical muscles, the superficial palmar arch, and the terminal branches of the median nerve; an *inner*, enclosing the short muscles of the little finger; and an *outer*, enclosing the short muscles of the thumb.

Dissection.—Raise the central part of the palmar fascia. Divide its narrow upper part, throw it downwards, and

finally remove it completely. The *superficial palmar arch* is the most superficial of the structures now exposed. Trace the ulnar artery into it, and follow the digital branches which it gives off. The median and ulnar nerves must also be dissected. The muscular branches, which the median gives to the muscles of the thenar eminence, are especially liable to injury. They come off in a short, stout stem, almost on a line with the lower margin of the anterior annular ligament, and at once turn outwards to reach the short muscles of the thumb, to some of which they are distributed. The nerve twigs to the two outer lumbricals must also be looked for carefully. They spring from the digital branches of the median, which go to the radial side of the index and to the cleft between the index and middle fingers.

In order that the digital vessels and nerves may be traced to their distribution, the skin must be reflected from the fingers. This can be done by making an incision along the middle of each digit, and turning the integument outwards and inwards. As the skin is raised from the lateral aspects of the different digits the *cutaneous ligaments of the phalanges* (Cleland) will come into view. These are fibrous bands, which spring from the edges of the phalanges behind the digital vessels and nerves. They are inserted into the skin so as to form a strong fibrous septum on each side of each finger. They retain the integument in proper position during the different movements of the digits.

Superficial Palmar Arch.—The ulnar artery, when traced into the palm, is found to form the superficial palmar arch—an arterial arcade, which lies immediately subjacent to the deep fascia. Detach the slip of fascia which binds the vessel to the front of the annular ligament. The arch is now exposed in its whole length.

The *ulnar artery* enters the palm by passing downwards in front of the annular ligament, close to the outer side

of the pisiform bone. A short distance below this it curves outwards, across the palm, and near the middle of the thenar eminence it is joined by the superficialis volae branch of the radial, or, more frequently, by a twig from the arteria radialis indicis or princeps pollicis. The convexity of the arch is directed downwards towards the fingers, and its lowest point corresponds with a line drawn across the palm from the lower border of the outstretched thumb.

Throughout its entire extent the superficial palmar arch lies very near the surface. Its inner part is covered by the palmaris brevis muscle; beyond this it is placed immediately behind the central part of the palmar fascia. As it is followed from the inner to the outer side of the hand it will be seen to rest upon—(*a*) the anterior annular ligament; (*b*) the short muscles of the little finger; (*c*) the flexor tendons and the digital branches of the median nerve.

Small branches proceed from the superficial palmar arch for the supply of the integument and adjoining short muscles of the palm. As the ulnar artery leaves the surface of the anterior annular ligament it gives off its *profunda branch;* whilst from the convexity of the arch proceed four *digital branches.*

The *profunda artery* is a small vessel, which at once disappears from view by passing backwards in the interval between the abductor minimi digiti and the flexor brevis minimi digiti. It will be traced to its termination in the deep dissection of the palm.

The *four digital arteries* form the palmar collateral branches for both sides of each of the three inner fingers and for the ulnar side of the index finger. The *first digital artery* runs downwards upon the short muscles of the little finger, to which it gives twigs, and then it is carried along the ulnar side of the little finger. The *second digital artery* proceeds towards the interval between the roots of the little and ring fingers, and divides into two branches (*collateral arteries*), which run along the contiguous sides of

these digits. The *third digital artery* supplies in like manner the adjacent sides of the ring and middle fingers; whilst the *fourth digital artery* deals similarly with the contiguous margins of the middle and index fingers.

There are certain points in connection with these digital arteries, during their course in the palm and along the sides of the fingers, which must be noted. In the *palm* the undivided trunks lie in the intervals between the flexor tendons, and in front of the digital nerves and the lumbrical muscles. Along the sides of the *fingers* they show a different relation to the nerves: the nerves are now in front, and the arteries behind. Upon the terminal phalanx the two collateral branches join to form an arch, from which proceed great numbers of fine twigs, to supply the pulp of the finger, and the bed upon which the nail rests.

Each digital artery at the point at which it divides is joined by the corresponding interosseous branch of the deep palmar arch. The collateral branches give a liberal supply of twigs to the integument, sheaths of the tendons, and joints of the fingers.

Median Nerve.—The median nerve enters the palm by passing *behind* the anterior annular ligament with the flexor tendons. In this part of its course it is enveloped by the synovial sheath which is wrapped around the tendons. Further, before it emerges it assumes a flattened form, and divides into two portions. Of these, the *external division* is slightly the smaller of the two, and gives off—(1) a stout short branch to some of the intrinsic muscles of the thumb; (2) three digital branches which go to the two sides of the thumb and the radial side of the index finger.

The *muscular branch* takes origin at the lower border of the annular ligament, and at once turns outwards to supply the abductor pollicis, the superficial head of the flexor brevis pollicis, and the opponens pollicis.

The *digital nerves* which run along the ulnar side of the thumb, and the radial side of the index, give several branches to the fold of integument which stretches between the roots of these digits; whilst the long digital branch to the radial border of the index gives a minute twig to the first or outermost lumbrical muscle.

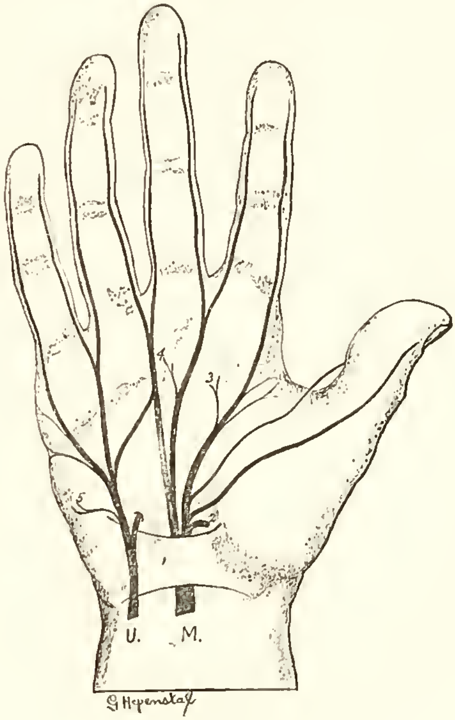

FIG. 23.

Diagram of the Median and Ulnar Nerves.

U. Ulnar nerve.
M. Median nerve.
1. Anterior annular ligament.
2. Muscular branch of median.
3 & 4. Branches to the two outermost lumbrical muscles.
5. Branch to palmaris brevis.

The larger *internal division* of the median nerve divides into two branches. Of these one runs towards the cleft between the index and middle fingers, and splits into the collateral branches for the adjacent sides of these digits.

From this nerve a twig to the second lumbrical muscle is given off. The second branch of the internal division of the median proceeds towards the cleft between the middle and ring fingers, and divides into the collateral branches for their contiguous margins.*

In the palm the digital branches of the median proceed downwards behind the superficial palmar arch, but as they approach the fingers they come to lie in front of the digital arteries which, in many cases, may be observed to pass through, or perforate, the nerves. As the digital nerves lie upon the sides of the fingers, numerous branches are given to the integument; and if the dissector exercises sufficient patience and care in the dissection, he will notice attached to the nerve twigs numerous minute, oval, seedlike bodies. These are the *Pacinian bodies*. At the extremity of the fingers the digital nerves divide into two terminal branches. Of these, one ramifies in the pulp, whilst the other inclines backwards to reach the bed upon which the nail rests.

The Ulnar Nerve enters the palm by passing *in front of* the annular ligament. It lies secure from the effects of pressure under the shelter of the pisiform bone, and upon the inner side of the ulnar artery. At this level it divides into two terminal branches—a superficial and a deep.

The *deep branch* of the ulnar is continued downwards upon the annular ligament, and associates itself with the profunda branch of the ulnar artery. It leaves the present dissection by passing backwards between the abductor and the flexor brevis muscles of the little finger.

The *superficial branch* of the ulnar nerve runs downwards under cover of the palmaris brevis, to which it gives a branch of supply, and then divides into two digital branches. One of these proceeds obliquely over the short

* In some instances this nerve supplies a twig to the third lumbrical muscle.

muscles of the little finger to gain the inner side of that digit; the other descends to the cleft between the little and ring fingers, and divides into the collateral branches for the adjacent sides of these digits. A branch of communication passes from the second digital branch of the ulnar nerve to the adjoining digital branch of the median nerve.

The digital branches of the ulnar nerve are distributed on the sides of the fingers in precisely the same manner as those derived from the median.

Anterior Annular Ligament.—This is a thick, dense, fibrous band, which stretches across the front of the carpal arch, so as to convert it into an osteo-fibrous tunnel for the passage of the flexor tendons into the palm. On each side it is attached to the two piers of the carpal arch, viz. on the *outer side* to the tubercle of the scaphoid and the ridge of the trapezium, and on the *inner side* to the pisiform bone and the hook of the unciform. Its upper margin is in a measure continuous with the deep fascia of the forearm, of which it may be considered to be a thickened part, whilst its lower margin is connected with the palmar fascia.

Upon the anterior surface of the annular ligament the expanded tendon of the palmaris longus is prolonged downwards to the central part of the palmar fascia, whilst on each side several of the short muscles of the thumb and little finger take origin from it. Close to its inner attachment the ulnar artery and nerve find their way into the palm by passing in front of the ligament, and a strong slip of fascia which bridges over these may be looked upon as an accessory attachment of the ligament, seeing that it springs from the pisiform bone and tendon of the flexor carpi ulnaris, and joins the front of the annular ligament beyond the artery and nerve.

The tunnel which the anterior annular ligament forms with the palmar concavity of the carpus is transversely

oval in shape, and below it opens into the middle compartment of the palm. Through it pass the tendons of the flexor sublimis, the flexor profundus digitorum, the tendon of the flexor longus pollicis, and the median nerve. The relation of the tendon of the flexor carpi radialis to the annular ligament is peculiar. It pierces the outer attachment of the ligament, and proceeds down in the groove of the trapezium in a special compartment provided with a special synovial sheath.

Synovial Sheaths of the Flexor Tendons.—As the flexor tendons and the median nerve pass through the carpal tunnel they are enveloped by two synovial sheaths, which at the same time line the walls of the canal, and thus greatly facilitate the free play of the tendons behind the anterior annular ligament. As we have stated, these sheaths are two in number. One is wrapped around the tendon of the flexor longus pollicis ; the other invests the tendons of the flexor profundus and flexor sublimis. Both are prolonged upwards into the forearm for an inch or more, and both are carried downwards into the palm in the form of diverticula upon the diverging tendons. The diverticula in relation to the tendons which go to the index, middle, and ring fingers, end near the middle of the palm. Those upon the tendons of the thumb and little finger, however, are prolonged downwards into these digits, and line the flexor sheaths which confine the tendons upon the palmar aspects of the phalanges.

It is not likely that these synovial sheaths have been preserved intact throughout the previous dissection of forearm and palm, but should they turn out to be uninjured, a very striking demonstration may be obtained by inflating them with air by means of the blow-pipe. The apertures through which the air is introduced should be made at the upper margin of the annular ligament.

It is said that the synovial sac which invests the tendons of the flexor sublimis and flexor profundus is divided by a

vertical partition into two compartments, and that the outer of these communicates, by means of a small aperture near the upper border of the annular ligament, with the synovial sheath of the tendon of the flexor longus pollicis.

Flexor Tendons.—Open the carpal tunnel by making a vertical incision through the anterior annular ligament at its middle. The arrangement of the flexor tendons can now be studied, and the synovial sheath dissected from the surface of each. The tendon of the *flexor longus pollicis* occupies the outer part of the canal, and gaining the palm turns outwards to reach the phalanges of the thumb. The four tendons of the *flexor sublimis* are arranged in pairs behind the annular ligament ; those for the little and index fingers lying behind those for the ring and middle fingers. Of the tendons of the *flexor profundus*, only that for the index finger is distinct and separate ; the other three remain united until they emerge from under cover of the annular ligament.

In the central compartment of the palm the flexor tendons diverge from each other, and two, viz. one from the flexor sublimis, and one from the flexor profundus, go to each of the four fingers. From the tendons of the flexor profundus, the lumbrical muscles take origin, and these, with the digital nerves and arteries, will be seen occupying the intervals between the tendons as they approach the roots of the fingers.

In the *fingers* the two flexor tendons run downwards upon the palmar aspect of the phalanges, and are held in position by the flexor sheaths. These, therefore, must be studied before the insertions of the tendons can be examined.

Flexor Sheaths—Insertions of Flexor Tendons.—The flexor sheaths of the fingers lie immediately subjacent to the skin and superficial fascia, and the digital vessels and nerves run downwards upon each side of them. Each of

these sheaths, with the phalanges of the fingers, forms an osteo-fibrous canal or tube. The deep wall of the tube is formed by the flat palmar surfaces of the phalanges; the front wall is composed of the fibrous sheath which bridges over the tendons, and is attached on each side to the sharp lateral margins of the phalanges. The strength of this sheath differs very much at different points. Opposite the centre of each of the two proximal phalanges it is composed of transverse fibres, and it acquires a great thickness and density forming a distinct arch, called the *vaginal ligament*. Such an arrangement over the joints, however, would seriously interfere with the free flexion of the fingers, and therefore in front of the articulations between the phalanges the sheath is exceedingly thin, and is strengthened by oblique interlacing fibres.

The flexor tubes in front of one or more of the fingers may now be opened. They will be seen to be lined by a synovial sheath, which is reflected over the enclosed tendons so as to give each a separate investment. The synovial sheath of the little finger has been seen to be a direct prolongation from the carpal synovial sheath; the other three are distinct from this, and are carried upwards into the palm. They envelope the tendons of the ring, index, and middle fingers, as far as a line drawn across the palm immediately above the heads of the metacarpal bones.

If the flexor tendons be raised from the phalanges, certain synovial folds will be noticed connecting them to the bones. These are termed the *vincula accessoria*. Of these we distinguish two kinds, viz. ligamenta brevia and longa. In the accompanying figure the connections of these may be seen. The *ligamenta brevia* (5 and 6) are triangular folds, which connect the tendons near their insertions to the anterior face of the phalanx. The *ligamenta longa* (4) are not invariably present. They are placed higher up, and are narrow, weak folds which pass between the tendons and the bones.

The insertions of the two tendons can now be studied. In front of the first phalanx the tendon of the flexor sublimis becomes flattened and folded round the subjacent cylindrical tendon of the flexor profundus. It splits into two parts, which pass behind the tendon of the flexor profundus, and allow it to pass onwards between them. Behind the deep tendon the two portions of the tendon of the flexor sublimis become united by their margins, and

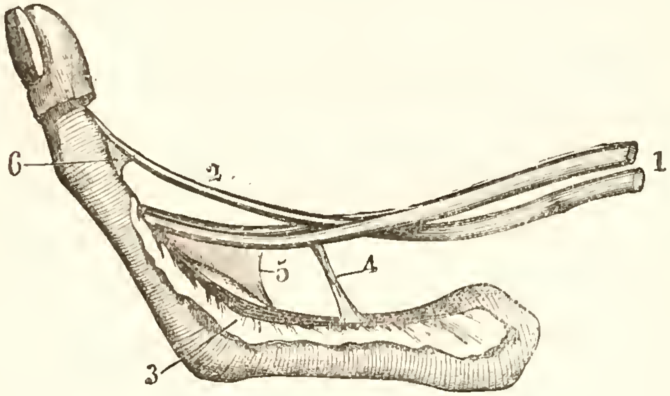

FIG. 24. (From Reeves.)

Flexor Tendons of the Finger, with the Vincula Accessoria.

1. Flexor sublimis tendon.
2. Flexor profundus tendon.
3. Flexor sheath turned aside.
4. Ligamentum longum.
5 & 6. Ligamenta brevia.

then they diverge, to be inserted into the borders of the shaft of the second phalanx.* By this arrangement the flattened tendon of the flexor sublimis forms a ring, through which the tendon of the flexor profundus is allowed to pass onwards to the base of the ungual phalanx, into which it is inserted. In each of the four fingers the same condition is found: the tendon of the flexor sublimis is inserted by two slips into the sides of

* Where the margins of the two slips of the tendon of the flexor sublimis are united behind the tendon of the flexor profundus, a decussation of fibres takes takes place between the two slips, and greatly strengthens the insertion.

the second phalanx, whilst the tendon of the flexor profundus is inserted into the anterior aspect of the base of the terminal phalanx.

Tendon of the Flexor Longus Pollicis.—This tendon proceeds downwards in the interval between two of the muscles of the thumb (viz. the superficial head of the flexor brevis pollicis, and the adductor obliquus pollicis), and the two sesamoid bones which play upon the head of the metacarpal bone. Reaching the proximal phalanx, it enters a fibrous sheath constructed upon a similar plan to those of the fingers. When this is opened, the tendon will be observed to be inserted into the front of the base of the terminal phalanx of the thumb. The synovial sheath which surrounds the tendon during its passage through the carpal tunnel is continuous with the sheath which invests the tendon in front of the phalanges.

Dissection.—Throw forward the superficial palmar arch. Divide it on the inside below the origin of the profunda artery, and on the outside at the point where it is joined by the superficial volar artery. The median nerve may also be severed and its branches turned aside, but care should be taken to preserve the two branches which it gives to the lumbrical muscles, and also the stout branch which enters the muscles of the thenar eminence. Lastly, cut through the fleshy belly of the flexor sublimis in the forearm, and raising its tendons from the carpal hollow, throw them as far down as possible. The tendons of the flexor profundus and the attached lumbrical muscles are now fully displayed.

The Lumbrical Muscles.—are four slender fleshy bellies which arise from the tendons of the flexor profundus as they traverse the palm. The *first lumbrical* arises from the outer side of the tendon for the index finger; the *second lumbrical* springs from the radial border of the tendon for

the middle finger; whilst the *third* and *fourth lumbricals* take origin from the adjacent sides of the tendons between which they lie (viz. the tendons for the medius, annularis, and minimus). The little muscles pass downwards and end in delicate tendons on the radial sides of the fingers. Each is inserted into the outer margin of the dorsal expansion of the extensor tendon, which lies upon the posterior aspect of the proximal phalanx.

Dissection.—The flexor profundus may be divided in the forearm and thrown downwards. Great care must be taken in raising the tendons and lumbrical muscles from the palm, because slender twigs from the deep branch of the ulnar nerve enter the two inner lumbrical muscles on their deep aspect. These can easily be secured if ordinary caution be observed. The deep palmar arch and the deep branch of the ulnar nerve are now exposed, and a favourable opportunity is given for studying the short muscles of the thumb and little finger.

Short Muscles of the Thumb.—The *abductor pollicis* forms the most prominent and external part of the ball of the thumb. The *superficial head of the flexor brevis pollicis* lies immediately to the inner side of the abductor, and by separating the one from the other, the *opponens pollicis* will be exposed. These three muscles lie to the outer side of the tendon of the flexor longus pollicis. To the inner side of this tendon, and placed deeply in the palm, is a fan-shaped muscular sheet imperfectly separated into an upper and lower part by the radial artery as it enters the palm. The upper muscle is the *adductor obliquus pollicis* (deep head of flexor brevis pollicis of English text-books); the lower muscle is the *adductor transversus pollicis* (the adductor pollicis of English text-books).*

* The names applied to these two muscles in English text-books are utterly opposed to their homologies, and suggest an erroneous conception of their nature.

In dissecting these muscles the muscular branch of the median nerve must be traced to those which lie upon the outer side of the long flexor tendon of the thumb, and the deep branch of the ulnar must be followed, and its branches to the two adductors of the thumb secured.

The *abductor pollicis* arises from the front of the annular ligament and the trapezium. It is inserted into the radial side of the base of the first phalanx of the thumb, and slightly into the extensor tendon on the dorsum of the first phalanx. Its nerve of supply comes from the median.

The *superficial head of the flexor brevis pollicis** takes origin from the annular ligament, and is inserted into the outer side of the base of the proximal phalanx of the thumb. It is supplied by the median nerve.

The *opponens pollicis* springs from the annular ligament and the ridge on the front of the trapezium. Its fibres spread out, and are inserted into the entire length of the radial border of the metacarpal bone of the thumb. Its nerve of supply is derived from the median.

The *adductor obliquus pollicis* arises from the bases of the second and third metacarpal bones, and likewise from the os magnum, the trapezium, the trapezoid, and the sheath of the flexor carpi radialis. From this origin the muscle proceeds downwards along the inner side of the tendon of the flexor longus pollicis, and is inserted into the ulnar side of the base of the proximal phalanx of the thumb. A strong slip will generally be seen to deviate outwards from the outer border of the muscle. This passes under cover of the long flexor tendon, and joins the superficial head of the flexor brevis pollicis. The adductor obliquus is supplied by the deep branch of the ulnar nerve.

The *adductor transversus pollicis* has a wide origin from the anterior face of the lower two-thirds of the shaft of the

* The term *superficial head*, applied to this muscle, suggests the presence of a *deep head*. Such a head is present. It is the *interosseous primus volaris* of Henle.

middle metacarpal bone, and from the fascia covering the interosseous muscles. Its fibres converge as they pass outwards, and are inserted along with the adductor obliquus into the ulnar side of the base of the first phalanx of the thumb. It is supplied by the deep branch of the ulnar nerve.

Two sesamoid bones are developed in connection with the tendons of the short muscles of the thumb as they are inserted on either side of the base of the proximal phalanx.

Short Muscles of the Little Finger.—The *abductor minimi digiti* lies on the inner and superficial aspect of the hypothenar eminence, and the *flexor brevis minimi digiti* upon its outer side. On separating these from each other, the *opponens minimi digiti* is seen on a deeper plane, and in the interval between them.

The *abductor minimi digiti* arises from the pisiform bone, and is inserted into the ulnar side of the base of the proximal phalanx of the little finger. It is supplied by the deep branch of the ulnar nerve.

The *flexor brevis minimi digiti* is composed of a single fleshy belly which springs from the hook of the unciform bone and the annular ligament, and is inserted into the ulnar side of the proximal phalanx of the little finger, in common with the abductor. This muscle is sometimes much reduced in size, and frequently more or less completely incorporated with the opponens. Its nerve supply comes from the deep branch of the ulnar nerve.

The *opponens minimi digiti* arises from the annular ligament, and the hook of the unciform bone and its fibres spread out to obtain insertion into the entire length of the ulnar margin of the metacarpal bone of the little finger. The deep branch of the ulnar gives it its nerve of supply.

The Deep Branch of the Ulnar Nerve springs from the parent trunk on the anterior aspect of the annular ligament, and gives off a branch which supplies the three short

muscles of the little finger. Accompanied by the deep branch of the ulnar artery, it then sinks into the interval between the abductor and flexor brevis minimi digiti, and turns outwards across the palm under cover of the flexor tendons. Near the radial border of the palm the deep branch of the ulnar nerve breaks up into terminal twigs, which supply the adductor transversus pollicis, the adductor obliquus pollicis, and the first dorsal interosseous muscle. In its course across the palm it lies along the concavity or upper border of the deep palmar arch, and sends three fine branches forwards in front of the three interosseous spaces. These supply the interosseous muscles in those spaces, while the two inner also give branches to the deep surfaces of the two inner lumbrical muscles.*

The deep branch of the ulnar may, therefore, be said to supply all the muscles of the palm which lie to the inner side of the tendon of the flexor longus pollicis, whilst the median supplies the three muscles which lie to the outer side of that tendon. There are two exceptions to this generalization, viz. the two outer lumbrical muscles, which lie upon the inner side of the tendon, and are yet supplied by the median.

Deep Palmar Arch.—The artery which takes the chief part in the formation of this arch is the radial. This vessel enters the palm, by coming forwards through the upper part of the interosseous space between the two heads of the first dorsal interosseous muscle. In the present state of the dissection it makes its appearance between the contiguous margins of the adductor obliquus and adductor transversus pollicis. It runs inwards upon the interossei muscles and the metacarpal bones immediately below their bases. As it approaches the fifth

* The third lumbrical has frequently a double nerve-supply, as it is not uncommon to find a second twig from the median entering its superficial aspect.

metacarpal bone it is joined by the deep branch of the ulnar artery, and in this manner the deep palmar arch is completed.

The deep palmar arch does not show so strong a curve as the superficial arch, and it is placed at a higher level in the palm. It is closely accompanied by the deep branch of the ulnar nerve; and is separated from the superficial palmar arch by the group of flexor tendons, the branches of the median nerve which occupy the middle compartment of the palm, and also at its inner part by the flexor brevis minimi digiti, under which the deep branch of the ulnar nerve passes to join the radial.

The *branches* which spring from the deep palmar arch are: (1) the *recurrent*—a few small twigs which run upwards in front of the carpus to anastomose with branches of the anterior carpal arch; (2) *superior perforating*, which pass backwards in the upper parts of the interosseous spaces to anastomose with the dorsal interosseous arteries; and (3) the *palmar interosseous*—three in number—which pass forwards in front of the interosseous spaces and unite near the roots of the fingers, with the corresponding digital arteries from the superficial palmar arch. Sometimes one or more of these branches enlarge and take the place of the corresponding digital arteries.

Arteria Radialis Indicis, and Arteria Princeps Pollicis.—These arteries spring from the radial as it proceeds forwards between the first and second metacarpal bones. To bring them into view, the adductor transversus, and the adductor obliquus pollicis must be detached from their origins and turned outwards. The radial artery is now seen coming forwards between the two heads of the first dorsal interosseous muscle.

The *arteria radialis indicis* runs downwards between the adductor transversus pollicis and the first dorsal interosseous muscle to the radial border of the index, along which it proceeds as its outer collateral branch.

The *arteria princeps pollicis* takes a course downwards and outwards under cover of the adductor obliquus pollicis, and gains the front of the metacarpal bone of the thumb. Here it lies behind the tendon of the flexor longus pollicis, and divides into the two collateral branches of the thumb. These branches make their appearance, in the interval, between the adductor obliquus and the superficial head of the flexor brevis pollicis, and are carried forward on either side of the tendon of the long flexor.

SURGICAL ANATOMY OF THE PALM AND FINGERS.

Palmar Abscess.—When an abscess forms in the middle compartment of the palm early surgical interference is urgently called for. The dense palmar fascia effectually prevents the passage of the pus forwards, whilst an easy route upwards into the forearm is offered to it by the open carpal tunnel, through which the flexor tendons enter the palm. It is absolutely necessary, therefore, that before this can occur the surgeon should make an opening in the palm by means of which the pus can escape.

In making such an incision it is a matter of the utmost importance to bear in mind the position of the various vessels which occupy the middle compartment of the palm. As we have stated, the level to which the superficial palmar arch descends can be indicated by drawing a line transversely across the palm from the lower margin of the outstretched thumb. The deep palmar arch lies half an inch higher. The digital arteries, which spring from the convexity of the superficial arch, run in a line with the clefts between the fingers. An incision, therefore, which is made below the superficial arch, and on a line with the central line of one of the fingers, may be considered free from danger in so far as the vessels are concerned.

Thecal Ganglion.—The loose synovial sheath which envelops the flexor tendons as they pass behind the anterior annular ligament has been noticed to extend upwards into the lower part of the forearm, and downwards into the palm. When this is attacked by inflammatory action it is apt to become distended with fluid, and the anatomical arrangement of parts at once offers an explanation of the appearance which is presented. There is a bulging in the palm, and a bulging in the lower part of the forearm, but no swelling at all at the wrist. Here the dense annular ligament resists the expansion of the synovial sheath, which therefore shows an hour-glass constriction at this point.

Fingers.—The fingers are very subject to an inflammatory process, termed *Whitlow*, and, in considering this, it is of importance to remember that the flexor fibrous sheath ends at the base of the distal phalanx in each digit. When the whitlow occurs below this, in the pulp of the finger, the vitality of the distal part of the ungual phalanx is endangered, but the flexor tendons may be regarded as being tolerably safe. When the inflammation occurs above this, and involves the flexor sheath, as it generally does, sloughing of the tendons is to be apprehended, unless an immediate opening is made. And no slight superficial incision will suffice. The knife must be carried backwards in the centre of the finger, so as to freely lay open the sheath containing the tendons. Early interference in cases of whitlow of the thumb and little finger is even more urgently required than in the case of the other three digits, because, as we have seen, the digital synovial sheaths of the former are, as a rule, offshoots from the great carpal bursa, and offer a ready means for the upward extension of the inflammatory action.

Every amputation of the fingers above the insertion of the tendons of the flexor profundus involves the opening of the flexor sheaths, and this no doubt explains the frequent occurrence of palmar trouble after operations of this kind. The open tubes offer a ready passage, by means of which septic material may travel upwards into the palm, and, in the case of the thumb and little finger, into the carpal tunnel and lower part of the forearm.

BACK AND OUTER BORDER OF THE FOREARM.

The cutaneous nerves and vessels in this region have already been studied. The parts which still require to be examined are:—

1. The deep fascia.
2. The supinator and extensor muscles.
3. The posterior interosseoûs artery.
4. The perforating or terminal branch of the anterior interosseous artery.
5. The posterior interosseous nerve.

Deep Fascia.—The deep fascia on the posterior aspect of the forearm is stronger than that which clothes it in front. At the elbow it is firmly attached to the condyles of the humerus and the olecranon process, and it receives a reinforcement of fibres from the tendon of the triceps

muscle. Here also it affords origin to the extensor muscles, and sends strong septa between them. At the wrist a thickened band—*the posterior annular ligament*—is developed in connection with it. This can readily be distinguished from the thinner portions of the fascia with which it is continuous above and below, and it will be observed to stretch obliquely from the styloid process of the radius inwards and downwards across the wrist to the inner side of the carpus.

The deep fascia should now be removed, but that portion of it near the elbow, which gives origin to the subjacent muscles, should be left in place. The posterior annular ligament should also be artificially separated from it, and retained *in situ*.

Superficial Muscles.—The muscles in this region consist of a superficial and a deep group. The *superficial muscles*, as we proceed from the outer to the inner border of the forearm, are:—the supinator longus, the extensor carpi radialis longior, the extensor carpi radialis brevior, the extensor communis digitorum, the extensor minimi digiti, the extensor carpi ulnaris, and the anconeus. This group therefore comprises one supinator, three extensors of the wrist, two extensors of the fingers, and a feeble extensor of the forearm at the elbow-joint, viz. the anconeus. In the lower part of the forearm the extensor communis digitorum is separated from the extensor carpi radialis brevior by a narrow interval, and in this appear two muscles belonging to the deep group. These turn round the outer border of the forearm upon the surface of the radial extensors of the wrist, and end in tendons which go to the thumb. The upper muscle is the extensor ossis metacarpi pollicis, and the lower muscle the extensor primi internodii pollicis. They are placed in close contact, and so intimately are their tendons connected that in many cases they appear at first sight to be blended together by their margins.

Four of the muscles arise by a common origin from the front of the external condyle of the humerus, and at the same time derive fibres from the investing fascia and the septa it sends in between them. These are the extensor carpi radialis brevior, the extensor communis digitorum, the extensor minimi digiti, and the extensor carpi ulnaris. The superficial muscles should be cleaned, and isolated as far as possible from each other.

The Supinator Longus lies more on the front than on the back of the forearm. It takes origin in the upper arm from the upper two-thirds of the external supracondyloid ridge of the humerus and from the external intermuscular septum. Near the middle of the forearm a flat tendon emerges from its fleshy belly, and this proceeds downwards to gain insertion into the outer aspect of the expanded lower extremity of the radius close to the base of the styloid process.

The Extensor Carpi Radialis Longior is placed behind the supinator longus. It arises from the lower third of the external supracondyloid ridge of the humerus, and from the external intermuscular septum. From the fleshy portion of the muscle a long tendon proceeds which passes under cover of the posterior annular ligament, and is inserted into the radial side of the base of the metacarpal bone of the index finger.

The Extensor Carpi Radialis Brevior is closely associated with the preceding muscle. It arises by the common extensor tendon from the external condyle of the humerus; it also derives fibres from the external lateral ligament of the elbow-joint, from the investing deep fascia, and the fibrous septa in connection with it. The tendon of the muscle accompanies that of the long radial extensor under cover of the posterior annular ligament, and is inserted into the radial side of the base of the third meta-

carpal bone immediately beyond the root of its styloid process.

The Extensor Communis Digitorum takes origin by the common tendon from the outer condyle of the humerus. The deep fascia and the intermuscular septa in relation to it also contribute fibres. Its fleshy belly in the lower part of the forearm sends out four tendons, which pass under cover of the posterior annular ligament. On the dorsum of the hand they diverge and proceed onwards to the four fingers. Their arrangement and attachments on the dorsum of the hand and fingers will be afterwards considered.

The Extensor Minimi Digiti is a slender fleshy belly which at first sight appears a part of the preceding muscle, but its tendon passes through a special compartment in the posterior annular ligament. It arises in common with the extensor communis digitorum.

The Extensor Carpi Ulnaris arises, by means of the common extensor tendon, from the outer condyle of the humerus, from the fascia of the forearm, and from the intermuscular septum between it and the extensor minimi digiti. In the middle third of the forearm it may also receive some fibres from the strong fascial layer which binds it to the posterior border of the ulna. The tendon does not become free from the fleshy fibres until it approaches close to the wrist. It occupies the groove on the posterior aspect of the lower end of the ulna, between the head and styloid process, and passing under cover of the annular ligament is inserted into the tubercle on the base of the metacarpal bone of the little finger.

The Anconeus is a short triangular muscle placed on the posterior aspect of the elbow-joint. It is frequently more or less directly continuous with the triceps, and this, together with the fact that it gets a special branch of

supply from the musculo-spiral nerve, has led many anatomists to regard it as a piece of the triceps muscle. This is not the case, however; it belongs to, and is therefore properly classified with, the group of muscles on the extensor aspect of the forearm.

The *anconeus* presents a narrow origin from the posterior aspect of the external condyle of the humerus. From this its fibres spread out—the upper fibres passing transversely inwards, whilst the others proceed inwards and downwards, with an increasing degree of obliquity as we approach the lower border. It is inserted into the outer surface of the olecranon process, and into the upper third of the posterior surface of the shaft of the ulna. The nerve of supply to the anconeus has already been dissected (p. 90). It is a long slender branch from the musculo-spiral, which descends to its destination in the substance of the internal head of the triceps. In addition to this, the lower part of the muscle usually receives a twig from the posterior interosseous nerve.

Dissection.—Reflect the extensor communis digitorum and the extensor minimi digiti. Divide the fleshy belly of each about its middle, and throw them upwards and downwards. In doing this the utmost care must be taken to secure and preserve the nerve-twigs from the posterior interosseous nerve which enter these muscles on their deep surface. The posterior interosseous artery and nerve, together with the deep muscles, are now exposed, and may be fully dissected. In cleaning the muscles care must be taken of the terminal part of the posterior interosseous nerve, which in the lower part of the forearm dips, under cover of the extensor secundi internodii pollicis, to reach the interosseous membrane and the back of the carpus. In following this part of the nerve, the terminal or perforating branch of the anterior interosseous artery will be seen appearing on the back of the forearm, under cover of the extensor secundi internodii pollicis.

Deep Muscles.—These are—(1) The supinator brevis; (2) the extensor ossis metacarpi pollicis; (3) the extensor primi internodii pollicis; (4) the extensor secundi internodii pollicis; and (5) the extensor indicis.

The supinator brevis will be recognized from the close manner in which it is applied to the upper part of the shaft of the radius. The other muscles take origin below this in the order in which they have been named. The attachments of the supinator brevis cannot be satisfactorily studied at present. They will be described at a later stage of the dissection.

The Extensor Ossis Metacarpi Pollicis arises from both bones of the forearm, and from the interosseous membrane which stretches between them. Its origin from the radius corresponds to the middle third of its posterior surface; its origin from the ulna is at a higher level from the outer part of the posterior aspect of the shaft immediately below the oblique line which marks the lower limit of the insertion of the anconeus. The muscle proceeds downwards and outwards, and comes to the surface in the interval between the extensor communis digitorum and the extensor carpi radialis brevior. Closely accompanied by the extensor primi internodii pollicis it crosses the two radial extensors. The tendon which issues from it at this point is continued downwards over the outer side of the expanded lower end of the radius, and under cover of the posterior annular ligament. It is inserted into the radial side of the base of the metacarpal bone of the thumb.

The Extensor Primi Internodii Pollicis is placed along the lower border of the preceding muscle. It arises from a small portion of the posterior aspect of the radius, and also from the interosseous membrane. Its tendon is closely applied to that of the extensor ossis metacarpi pollicis, and accompanies it under the posterior annular ligament. It may be traced on the dorsal aspect of the metacarpal bone

of the thumb to the base of the proximal phalanx, into which it is inserted.

The Extensor Secundi Internodii Pollicis takes origin from the outer part of the posterior surface of the shaft of the ulna in its middle third, and also from the interosseous membrane. It to some extent overlaps the preceding muscle, and ends in a tendon which passes under cover of the posterior annular ligament. Here it occupies a deep narrow groove on the back of the lower end of the radius. On the carpus it takes an oblique course, and, crossing the tendons of the two radial extensors and the radial artery, reaches the thumb. It is inserted into the base of the distal phalanx of that digit.

By powerfully extending the thumb, the tendons of its three extensors become prominent on the outer aspect of the wrist. The oblique course of the tendon of the extensor secundi internodii is rendered evident, and a distinct depression between it and the other two tendons is seen.

The Extensor Indicis arises from a limited area on the posterior surface of the ulna and from the interosseous membrane below the preceding muscle. Its tendon accompanies those of the extensor communis under cover of the posterior annular ligament, and will afterwards be traced to its insertion in the index finger.

Posterior Interosseous Artery.—This vessel arises in the front of the forearm, from the common interosseous branch of the ulnar artery. It at once proceeds backwards between the two bones of the forearm, in the interval between the upper border of the interosseous membrane and the oblique ligament. In the present dissection it makes its appearance between the contiguous borders of the supinator brevis and the extensor ossis metacarpi pollicis, and then it extends downwards between the superficial and deep muscles on the back of the forearm. It gives branches

to these, and by the time it has reached the lower end of the forearm it is greatly reduced in size. In a well-injected limb it will be seen to end on the back of the carpus by anastomosing with the anterior interosseous and the posterior carpal arteries. In addition to the branches which it supplies to the muscles, it gives off one large branch called the *posterior interosseous recurrent.*

The *posterior interosseous recurrent* artery takes origin from the parent trunk as it appears between the supinator brevis and the extensor ossis metacarpi pollicis, and turns upwards, under cover of the anconeus muscle, to reach the posterior aspect of the outer condyle of the humerus. The anconeus should be detached from its origin and thrown inwards, in order that the artery may be traced to its termination. The interosseous recurrent artery will then be seen to end by anastomosing with the posterior terminal branch of the superior profunda artery.

The Anastomosis around the elbow-joint should now be reviewed as a whole. A distinct inosculation will be found to take place upon both the anterior and posterior aspect of each condyle of the humerus. Behind the external condyle the *posterior interosseous recurrent* joins the *posterior branch* of the *superior profunda* : in front of the same condyle the *anterior branch* of the *superior profunda* communicates with the *radial recurrent.* On the inner side of the joint the *anterior* and *posterior ulnar recurrent* arteries ascend respectively in front of and behind the internal condyle, and anastomose, the former with the *anterior branch of the anastomotic*, and the latter with the *posterior branch of the anastomotic* and the *inferior profunda.*

In this sketch of the anastomosis around the elbow-joint only the leading inosculations are mentioned. Rich networks of fine vessels, however, are formed over the olecranon process and the two condyles of the humerus. One very distinct and tolerably constant arch requires special mention. It is formed by a branch which crosses

the posterior aspect of the humerus immediately above the olecranon fossa, and connects the posterior branch of the superior profunda with the posterior branch of the anastomotica.

The Posterior Interosseous Nerve is one of the two terminal branches of the musculo-spiral (p. 104), and it reaches the back of the forearm by traversing the substance of the supinator brevis, and at the same time winding round the outer aspect of the shaft of the radius. It emerges from the supinator brevis a short distance above the artery of the same name, and is carried downwards between the superficial and deep muscles on the back of the forearm. Reaching the upper border of the extensor secundi internodii pollicis, it leaves the posterior interosseous artery, dips under cover of that muscle, and joins the anterior interosseous artery on the posterior aspect of the interosseous membrane. It will afterwards be traced to the back of the carpus, where it ends, under cover of the tendons of the extensor communis digitorum, in a gangliform enlargement.

The *branches* which spring from the posterior interosseous nerve in the forearm are given entirely to muscles. Before it pierces the supinator brevis it gives branches both to it and to the extensor carpi radialis brevior. After it appears on the back of the forearm it supplies the extensor communis digitorum, the extensor minimi digiti, the extensor carpi ulnaris, the three extensors of the thumb, and the extensor indicis. It therefore supplies all the muscles on the outer and back aspects of the forearm, with the exception of the supinator radii longus, the extensor carpi radialis longior, and the anconeus, which derive their nerve supply directly from the musculo-spiral.

Terminal Branch of the Anterior Interosseous Artery.—The terminal or perforating branch of the anterior interosseous artery is a vessel of some size. It appears through

the interosseous membrane, about two inches or so above the lower end of the forearm. Accompanied by the posterior interosseous nerve, it runs downwards, under cover of the extensor secundi internodii pollicis, and ends on the back of the carpus by anastomosing with the posterior carpal arch and the posterior interosseous artery.

DORSAL ASPECT OF THE WRIST AND HAND.

Upon the dorsal aspect of the wrist and hand we have still to examine—

1. The radial artery and its branches.
2. The posterior annular ligament.
3. The extensor tendons of the fingers.

Radial Artery.—It is only a small portion of the radial artery that is seen in this dissection. At the lower end of the radius the vessel turns backwards below the styloid process, and upon the external lateral ligament of the radio-carpal joint. Having gained the dorsal aspect of the carpus, it runs downwards upon the scaphoid and trapezium, and finally disappears from view by turning forwards through the upper part of the first interosseous space, and between the heads of origin of the first dorsal interosseous muscle. In the palm it takes the chief share in the formation of the deep palmar arch.

While the radial artery rests on the external lateral ligament, it is deeply placed, and is crossed by the tendons of the extensor ossis metacarpi and the extensor primi internodii pollicis. On the carpus it lies nearer the surface, and is crossed obliquely by the third extensor tendon of the thumb, viz. the tendon of the extensor secundi internodii pollicis. It is accompanied by two *venae comites* and some fine filaments from the musculo-cutaneous nerve which twine around it.

The *branches* which spring from the radial artery in this part of its course are of small size. They are—

1. The posterior radial carpal.
2. The first dorsal interosseous.
3. The two arteriae dorsales pollicis.
4. The arteria dorsalis indicis.

The *posterior radial carpal artery* takes origin on the outer aspect of the wrist, and runs inwards upon the carpus, to join the corresponding carpal branch of the ulnar artery. The arch thus formed is placed under cover of the extensor tendons, and gives off two branches which run downwards in the third and fourth inter-metacarpal intervals. They are termed the *second* and *third dorsal interosseous* arteries.

The *first dorsal interosseous artery* arises, as a rule, from the radial trunk, although not unfrequently it may be seen to spring from the posterior carpal arch. It extends downwards in the second inter-metacarpal interval.

The three dorsal interosseous arteries are brought into connection with the arteries in the palm by communicating branches. They are joined by the three perforating twigs of the deep palmar arch. These make their appearance on the dorsum between the heads of the three inner dorsal interosseous muscles. Further, at the lower ends of the interosseous spaces the dorsal interosseous arteries usually send *inferior perforating branches* to join the corresponding digital arteries in the palm.

The *two dorsal arteries of the thumb* run downwards upon either side of that digit.

The *dorsal artery of the index* is distributed on the radial side of the index.

Posterior Annular Ligament.—This has been seen to be an aponeurotic band which stretches obliquely across the wrist. It is merely a thickened portion of the deep fascia, and its attachments are so arranged that it does not inter-

fere with the free movement of the radius and hand during pronation and supination. On the outer side it is fixed to the outer margin of the lower end of the radius, whilst on the inner side it is attached to the cuneiform and pisiform bones, and also to the palmar fascia. In the case of the anterior annular ligament one large compartment, or tunnel, is formed for the flexor tendons: not so in the case of the posterior annular ligament. Partitions or processes pro-

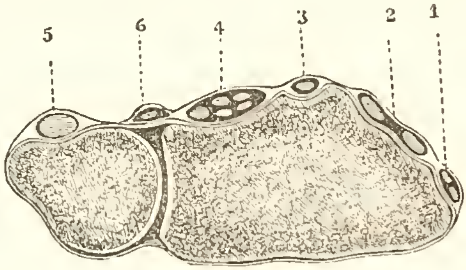

FIG. 25. (From Reeves, slightly modified.)

Section through the Lower End of the Forearm, to show the Compartments of the Posterior Annular Ligament.

1. First compartment, with the tendons of the extensor ossis and extensor primi internodii pollicis.
2. Second compartment, with the tendons of the two radial extensors.
3. Third compartment, with tendon of extensor secundi internodii pollicis.
4. Fourth compartment, with the tendons of the extensor communis and extensor indicis.
5. Fifth compartment, with the tendon of the extensor minimi digiti.
6. Sixth compartment, with the tendon of the extensor carpi ulnaris.

ceed from its deep surface, and these are attached to the ridges on the dorsal aspect of the lower end of the radius, so as to form a series of six bridges or compartments for the tendons. Each of these is lined by a special synovial sheath, to facilitate the play of the tendons within it. The different compartments may now be successively opened up, so that the arrangement of the tendons with reference to the posterior annular ligament may be studied.

The *first compartment* is placed on the outer side of the base of the styloid process of the radius, and corresponds with the broad oblique groove which is present in this part

of the bone. It contains two tendons, viz. the tendons of the extensor ossis metacarpi and the extensor primi internodii pollicis. The *second compartment* corresponds with the outermost groove on the dorsal aspect of the radius. This is broad and shallow, and it holds the tendons of the extensor carpi radialis longior, and of the extensor carpi radialis brevior. The *third compartment* is formed over the narrow deep intermediate groove on the back of the lower end of the radius, and through it the tendon of the extensor secundi internodii pollicis passes obliquely. The *fourth compartment* is placed over the wide shallow groove which marks the inner part of the dorsal aspect of the lower end of the radius. It is traversed by five tendons, viz. the four tendons of the common extensor and the tendon of the extensor indicis. The *fifth compartment* is situated over the interval between the lower ends of the radius and ulna. It contains the slender tendon of the extensor minimi digiti. The *sixth and innermost compartment*, which corresponds with the groove on the back of the lower end of the ulna, holds the tendon of the extensor carpi ulnaris.

Extensor Tendons of the Fingers.—The four tendons of the *extensor communis*, when they emerge from their compartment in the posterior annular ligament, diverge on the dorsum of the hand to reach the four fingers. The tendon of the ring finger will be seen to be connected by a tendinous slip with the tendon on either side of it. This explains the small degree of independent movement in a backward direction which the ring digit possesses. The arrangement of the tendons on the fingers is the same in each case. Upon the dorsal aspect of the first phalanx the tendon expands so as to cover it completely. Into the margins of this '*dorsal expansion*' the delicate tendons of the lumbrical and interosseous muscles are inserted. Near the first inter-phalangeal joint the expansion separates into three portions—a central and two lateral. The *central part*, which is the weakest, is inserted into the dorsal aspect

of the base of the second phalanx. The *stronger lateral portions* unite into one piece beyond this, and gain an insertion with the base of the ungual phalanx.

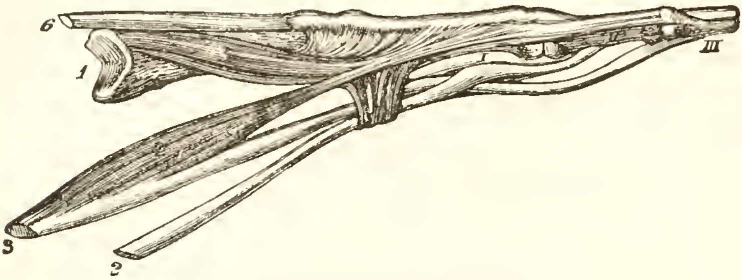

FIG. 26. (From Luschka.)

1. Middle metacarpal bone.
2. Tendon of flexor sublimis.
3. Tendon of flexor profundus.
4. Second lumbrical muscle.
5. Second dorsal interosseous muscle.
6. Extensor tendon.

I., II., and III. The three phalanges.

The tendon of the *extensor indicis* joins the expansion of the extensor tendon on the dorsal aspect of the first phalanx of the index finger.

The tendon of the *extensor minimi digiti* splits into two parts. Of these the *outer* joins the tendon of the common extensor which goes to that digit, whilst the *inner* ends in the dorsal expansion.

Posterior Interosseous Nerve.—The terminal filament of this nerve can now be traced downwards to the dorsal aspect of the carpus. It passes under cover of the extensor indicis, the tendons of the extensor communis, and the posterior annular ligament. On the carpus it ends in a gangliform swelling, from which proceed fine twigs for the supply of the numerous joints in the vicinity.

Transverse Metacarpal Ligament.—The limb should now be turned round, so that the transverse metacarpal ligament which stretches across the palmar surface of the heads of the metacarpal bones may be examined previous to the dissection of the interosseous muscles.

The *transverse metacarpal ligament* is a strong band composed of transverse fibres, which is placed upon the palmar aspect of the heads of the four metacarpal bones of the fingers. Commencing on the outer side upon the distal extremity of the index metacarpal, it ends at the inner margin of the hand upon the head of the metacarpal bone of the little finger. It is not directly attached to the bones, but is fixed to the powerful anterior ligaments of the four inner metacarpo-phalangeal joints, and it effectually prevents excessive separation of the metacarpal bones from each other.

The Interosseous Muscles occupy the intervals between the metacarpal bones. To obtain a satisfactory view of them the adductor transversus pollicis should be detached from its origin, and thrown outwards towards its insertion into the thumb. The transverse metacarpal ligament must also be divided in the intervals between the fingers. The interosseous muscles are seven in number; and are arranged in two groups, viz. a dorsal and a palmar.

The dorsal interossei are four in number, and are more powerful than the palmar muscles. They are best seen on the dorsal aspect of the hand, but they are also visible in the palm. They act as abductors of the fingers from a line drawn through the middle digit, and their insertions are arranged in accordance with this action. Each muscle arises by two heads from the contiguous surfaces of the two metacarpal bones between which it lies, and the fibres converge in a pennate manner upon a delicate tendon. In the case of *the first* or *outermost dorsal interosseous muscle*, this tendon is inserted into the radial side of the base of the first phalanx, and also into the radial margin of the dorsal expansion of the extensor tendon of the index. The *second* and *third dorsal interosseous muscles* are inserted in a similar manner upon either side of the base of the first phalanx of the middle finger; whilst the *fourth* has a corresponding insertion upon the ulnar aspect of the base of the first phalanx of the ring finger.

The first dorsal interosseous muscle is frequently termed the *abductor indicis*, and between its two heads of origin the

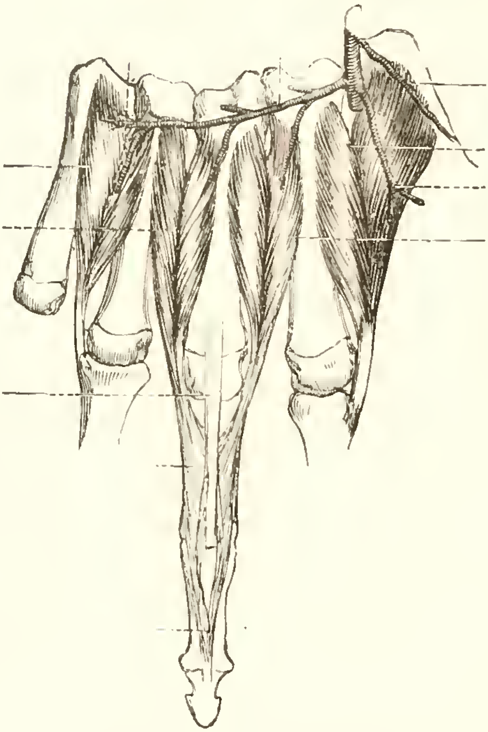

FIG. 27. (From Reeves.)

Dorsal Interosseous Muscles.

radial artery enters the palm. Between the heads of the other three muscles the small posterior perforating arteries pass.

The three *palmar interosseous muscles* can only be seen on the palmar aspect of the hand. They act as adductors of the index, ring, and little fingers towards the middle digit, and each muscle is placed upon the metacarpal bone of the finger upon which it acts. The *first palmar interosseous muscle* therefore arises from the metacarpal bone of the index finger, and its delicate tendon is inserted upon the ulnar side of that digit, partly into the base of the first

phalanx, and partly into the extensor expansion. The *second palmar interosseous muscle* springs from the metacarpal bone of the ring finger, and has a similar insertion into the radial side of that digit. The *third palmar interosseous muscle* takes origin from the metacarpal bone, and presents a corresponding insertion into the radial side of the first phalanx and extensor expansion of the little finger. The interosseous muscles are supplied by the deep branch of the ulnar nerve.

Deep Head of the Flexor Brevis Pollicis (Interosseous primus volaris of Henle).—This minute muscle can best be displayed from the dorsal aspect of the hand by reflecting the radial head of the first dorsal interosseous muscle. It arises from the base of the metacarpal bone of the thumb, and is inserted into the ulnar sesamoid bone of that digit. It is deeply placed, and is entirely covered from the front by the adductor obliquus pollicis.

Tendon of the Flexor Carpi Radialis.—The tendon of this muscle should now be traced through the groove on the front of the trapezium to its insertion into the base of the metacarpal bone of the index. It presents also a minor attachment to the base of the middle metacarpal bone.

ARTICULATIONS.

Dissection.—All the muscles around the elbow-joint should be removed. In raising the brachialis anticus and the triceps from the front and back of the articulation, some care is required to avoid injury to the anterior and posterior ligaments. It is advisable to remove the supinator brevis last, because it is only when this muscle is completely isolated that a proper idea of its attachments and mode of action can be obtained.

Supinator Radii Brevis.—The supinator brevis envelops the upper part of the shaft and the neck of the radius, covering it completely, except on its inner side. It arises from the deep depression below the lesser sigmoid cavity of the ulna, and also from the external lateral ligament of the elbow and the orbicular ligament of the radius. Its

insertion is into the radius upon which its fibres extend as far down as the insertion of the pronator radii teres. The posterior interosseous nerve traverses the substance of the muscle, and separates into two layers.

Elbow-joint.—At the elbow-joint the trochlear surface of the humerus is grasped by the greater sigmoid cavity of the ulna. The shallow depression on the upper surface of the head of the radius rests upon the capitellum of the humerus, and its slightly raised rim occupies the groove on the lower end of the humerus between the capitellum and the trochlea.

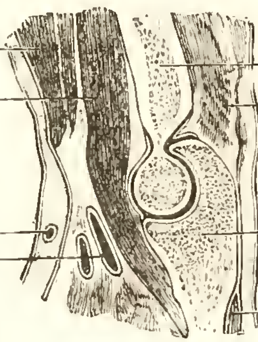

FIG. 28.

Vertical Section through Humerus and Ulna at the Elbow-joint.

The *ligaments* of the elbow-joint are arranged in the form of a capsule which surrounds the articulation on all sides. From the differences which this exhibits in strength and attachments four portions are recognized. These are—

1. The external lateral ligament.
2. The internal lateral ligament.
3. The anterior ligament.
4. The posterior ligament.

The External Lateral Ligament is a strong but short ligamentous band which is attached above to the lower aspect of the external condyle of the humerus. Below, it is fixed to the orbicular ligament of the radius, and also to

the outer side of the olecranon process of the ulna behind this. The orbicular ligament, as we shall afterwards see, is a strong ligamentous collar which surrounds the head of the radius, and retains it in the lesser sigmoid cavity of the ulna.

The Internal Lateral Ligament is fan-shaped. By its upper pointed part it is attached to the internal condyle of the humerus. Inferiorly it spreads out to find insertion into the coronoid and olecranon processes of the ulna. When carefully dissected it will be noticed to consist of three portions, viz. an anterior, a posterior, and a transverse.

The *anterior part* springs from the lower and front part of the humeral condyle, and is attached to the inner margin of the coronoid process of the ulna. The *posterior part* is attached above to the lower and back part of the humeral condyle, whilst below it is fixed to the inner border of the olecranon process. The *transverse part* consists of a narrow band of fibres, which bridges across the notch between the olecranon and the coronoid process, and is attached to both.

The Anterior Ligament is broad, and composed of fibres which take an irregular course over the anterior aspect of the joint. It is attached to the front of the humerus above the coronoid fossa, whilst below it is inserted into the margin of the coronoid process of the ulna, and also into the orbicular ligament of the radius.

The Posterior Ligament is weaker than the anterior. It has a loose attachment to the back of the humerus, above the olecranon fossa, and inferiorly it is fixed to the olecranon and the orbicular ligament of the radius.

Synovial Membrane.—The joint should be opened by making a transverse incision through the anterior ligament. The synovial membrane will be seen lining the deep surface of the ligamentous capsule, and reflected from this upon the non-articular parts of the bones which are enclosed within the ligaments. In front of the humerus

it lines the radial and coronoid fossae, and behind it is prolonged upwards in the form of a loose diverticulum into the olecranon fossa. In these fossæ a quantity of soft oily fat is developed in connection with the synovial

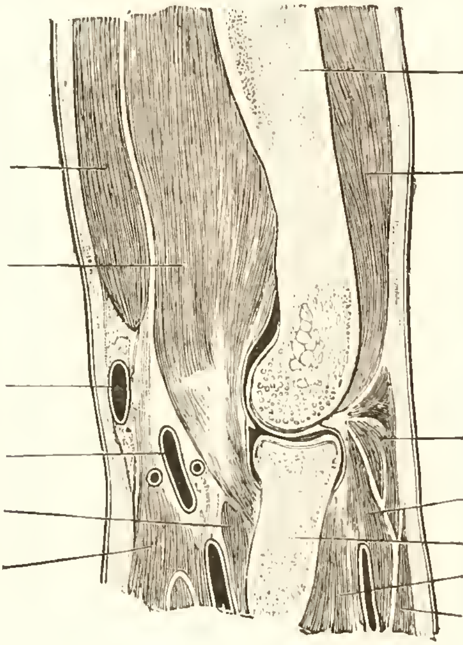

FIG. 29.

Vertical Antero-posterior Section through the Humerus and Radius at the Elbow-joint.

membrane, and occupies the recesses when the bony processes are withdrawn from them.

Inferiorly the synovial membrane of the elbow-joint is prolonged downwards into the superior radio-ulnar joint, so that both articulations possess a single continuous synovial cavity.

Movements at the Elbow-joint.—The movements at the elbow-joint must not be confounded with those that take place at the superior radio-ulnar joint. At the elbow-joint two movements, viz. *flexion*, or forward movement of the forearm, and *extension*, or backward movement of the forearm, are permitted.

The muscles which are chiefly concerned in flexing the forearm upon the upper arm at the elbow-joint are the biceps, the brachialis anticus, the pronator radii teres, and the supinator longus. The muscles which extend the forearm at this articulation are the triceps and anconeus.

Radio-carpal Joint.—It is advisable to study the radio-carpal, or wrist-joint before the articulations between the two bones of the forearm are examined. The anterior and posterior annular ligaments, together with the extensor and flexor tendons, should be completely removed from the wrist. No attempt, however, should be made to detach the extensor tendons from the back of the fingers and thumb. The short muscles of the thenar and hypothenar eminences must also be taken away.

In the radio-carpal joint, the under surface of the radius, with a triangular plate of fibro-cartilage on its inner side, forms a shallow socket for the scaphoid, semilunar, and cuneiform bones. The ulna does not take part in this articulation, as the triangular fibro-cartilage is interposed between its lower end and the carpus.

The ligaments which retain the opposed surfaces in contact with each other are four in number, viz.—

1. Anterior.
2. Posterior.
3. Internal.
4. External.

The Anterior Ligament is strong and broad, and it is composed of fibres which run in different directions, although those which pass obliquely downwards and inwards predominate. Above it is attached to the lower border of the inferior expanded extremity of the radius; and below, it is inserted into the bones which constitute the first row of the carpus, with the exception of the pisiform, viz. into the scaphoid, semilunar, and cuneiform. Some of the fibres may be traced beyond the first carpal row into the os magnum.

The Posterior Ligament is weak in comparison with the anterior ligament. The direction of its fibres is for the

most part downwards and inwards. It arises above from the posterior aspect of the lower end of the radius, and is attached below to the scaphoid, semilunar, and cuneiform bones.

The External Lateral Ligament passes from the tip of the styloid process of the radius to the scaphoid bone.

The Internal Lateral Ligament is round and cord-like. It stretches from the styloid process of the ulna to the cuneiform and pisiform bones.

The four ligaments which we have described in connection with the radio-carpal joint are more or less directly continuous with each other, and in consequence they form a capsule around the articulation.

Articular Surfaces.—Divide the anterior and lateral ligaments of the radio-carpal joint by a transverse incision carried across the front of the articulation. The hand can now be bent backwards, so as to expose fully the articular surfaces opposed to each other in this joint.

The *carpal surface* is composed of the superior articular facets of the scaphoid and semilunar bones, and a very small articular facet on the extreme outer part of the upper surface of the cuneiform bone. Two interosseous ligaments stretch across the narrow intervals between these bones—one on either side of the semilunar—and complete the carpal surface. Formed of these factors, the carpal surface is convex both from before backwards and from without inwards. Further, it should be observed that it extends downwards to a greater extent behind than in front.

The *upper surface* or *socket* is elongated from side to side, and concave in both directions, viz. from before backwards and from without inwards. The greater part of it is formed by the lower end of the radius, but to the inner side of this the triangular fibro-cartilage of the inferior radio-ulnar joint

likewise enters into its construction. The lower surface of the radius is divided by a low ridge into an outer triangular and an inner quadrilateral facet. The outer facet, in the ordinary position of the hand, is in contact with the greater extent of the superior articular surface of the scaphoid. The inner facet of the radius, with the triangular fibro-cartilage, forms a much larger surface, triangular in outline, which is opposed to the superior articular surface of the semilunar. When the hand is placed in line with the forearm no part of the upper articular surface is allotted to the cuneiform ; its small articular facet rests against the inner part of the capsule of the joint. When the hand is moved inwards (*i. e.* adducted), however, the cuneiform bone travels outwards, and its articular surface comes into contact with the under surface of the triangular fibro-cartilage. The semilunar bone at the same time crosses the bounding ridge on the lower surface of the radius, and encroaches on the territory of the scaphoid, whilst a considerable part of the scaphoid surface leaves the radius, and comes into contact with the outer part of the capsule.

Synovial Membrane.—The synovial membrane of the radio-carpal joint lines the deep surfaces of the ligaments forming the capsule, and between the carpal bones it covers the upper surfaces of the two interosseous ligaments which complete the carpal surface. Sometimes the triangular fibro-cartilage is imperfect, and in these cases the synovial membrane of the radio-carpal joint becomes continuous with the synovial membrane of the inferior radio-ulnar joint.

Movements at the Radio-carpal Joint.—The hand can be moved in four directions at the radio-carpal joint. Thus we have—(*a*) forward movement, or *flexion* ; (*b*) backward movement, or *extension* ; (*c*) inward movement, or *adduction* ; (*d*) outward movement, or *abduction*. In estimating the extent of these movements in the living person the student is apt to be misled by the increase of range which is con-

tributed by the carpal joints. Thus, flexion at the radio-carpal joint is in reality more limited than extension, although by the combined action of both carpal and radio-carpal joints the hand can be carried much more freely forwards than backwards. Adduction, or ulnar flexion, can be produced to a greater extent than abduction, or radial flexion. The styloid process of the radius interferes with abduction. The *muscles* which are chiefly concerned in producing these different movements of the hand at this joint are the following:—(*a*) *flexors*—the flexor carpi radialis, the palmaris longus, and the flexor carpi ulnaris; (*b*) *extensors*—extensor carpi radialis longior, the extensor carpi radialis brevior, and the extensor carpi ulnaris; (*c*) *abductors*, or *radial flexors*—flexor carpi radialis, extensor carpi radialis longior, extensor ossis metacarpi pollicis, and the extensor primi internodii pollicis; (*d*) *adductors*, or *ulnar flexors*—extensor carpi ulnaris and flexor carpi ulnaris.

Radio-ulnar Joints.—At the radio-ulnar joints the movements of pronation and supination take place. They are two in number, viz. a superior and an inferior. At the *superior radio-ulnar articulation* the inner part of the head of the radius fits into the lesser sigmoid cavity of the ulna; at the *inferior radio-ulnar joint* the small rounded extremity of the ulna is received into the sigmoid cavity on the inner side of the lower end of the radius. In connection with these joints there are special ligaments which retain the bones in apposition. These are—(1) for the superior radio-ulnar joint, *the orbicular ligament;* and (2) for the inferior radio-ulnar joint (*a*), an *anterior* and *posterior ligament*, and (*b*) a connecting *triangular fibro-cartilage.*

In addition there are other ligaments which pass between the shafts of the two bones of the forearm, and are therefore common to the two articulations, viz. *the oblique ligament* and the *interosseous membrane.* To expose these the muscles on the front and back of the forearm must be completely removed.

Orbicular Ligament.—This is a strong ligamentous collar which encircles the head of the radius, and retains it in the lesser sigmoid cavity of the ulna. It forms four-

fifths of a circle, and is attached by its extremities to the ulna, in front and behind the lesser sigmoid cavity. It is somewhat narrower below than above, so that under no circumstances could the head of the radius be withdrawn from it in a downward direction, and it is braced tightly upwards towards the elbow, and greatly strengthened by certain ligaments of the elbow-joint which become incorporated with it along its upper border. These are, on the outer side, the external lateral ligament of the elbow, in front a portion of the anterior ligament, and behind a portion of the posterior ligament of the elbow-joint. Its lower border is free, and protruding downwards below this will be seen a reflection of the synovial membrane.

Anterior and Posterior Inferior Radio-ulnar Ligaments.—These are weak, imperfect bands which can have little influence in retaining the bones in apposition at the inferior radio-ulnar joint. They pass between the radius and ulna in front and behind the articulation, and close in the synovial membrane upon these aspects.

The Triangular Fibro-cartilage is the true bond of union at the inferior radio-ulnar joint. It has already been noticed in connection with the radio-carpal joint, where it extends the radial articular surface in an inward direction, and is interposed between the lower end of the ulna and the semilunar bone. It is a thick, firm plate, attached by its base to the margin on the inner and lower end of the radius which intervenes between the sigmoid cavity for the ulna, and the facet on its lower surface for the semilunar bone. Its apex is directed inwards, and is fixed to the depression on the lower end of the ulna at the root of the styloid process. It intervenes between the inferior radio-ulnar joint and the radio-carpal joint.

Synovial Membranes.—The synovial membrane of the superior radio-ulnar joint is continuous with that of the elbow-joint. It is prolonged downwards so as to line

the orbicular ligament, and it protrudes beyond this for a short distance upon the neck of the radius.

In the inferior radio-ulnar joint the synovial membrane is remarkable for its laxity. It is called the *membrana sacciformis*, and extends upwards in the form of a loose sac for some distance between the radius and ulna. The synovial cavity is also prolonged inwards in a horizontal direction between the lower end of the ulna and the triangular fibro-cartilage.

Sometimes the triangular fibro-cartilage is perforated; and when this is the case, the inferior radio-ulnar joint-cavity communicates with the cavity of the radio-carpal joint.

The Interosseous Membrane is a fibrous membrane which is stretched across the interval between the two bones of the forearm, and is attached to the interosseous border of each. Superiorly it is deficient. Its upper border does not reach higher than a point about an inch below the tubercle of the radius. The fibres which compose it run for the most part obliquely downwards and inwards from the radius to the ulna, although several slips may be noticed taking an opposite direction. The posterior interosseous vessels pass backwards between the two bones of the forearm immediately above its upper margin, whilst the terminal branch of the anterior interosseous artery pierces it about one and a-half inches above its lower end. This ligament, in addition to bracing the two bones together, extends the surface of origin for the muscles of the forearm. By its anterior surface it gives origin to the flexor profundus and the flexor longus pollicis muscles, whilst by its posterior surface it contributes fibres to the three extensor muscles of the thumb and to the extensor indicis.

The Oblique Ligament is a weak slip which springs from the outer part of the coronoid process of the ulna, and

extends obliquely downwards and outwards to find an attachment to the radius immediately below its bicipital tubercle. It crosses the open space between the bones of the forearm above the upper border of the interosseous membrane. The oblique ligament is often absent, and unless the utmost care be taken in removing the muscles in preparation of the ligaments it is apt to be injured.

Movements at the Radio-ulnar Joints.—At the radio-ulnar joints the movements of pronation and supination take place. When the limb is in a condition of complete supination the palm of the hand is directed forwards, the thumb outwards, and the two bones of the forearm are parallel, the radius lying along the outer side of the ulna. In the movement of pronation the radius is thrown across the ulna, so that its lower end comes to lie on the inner side and in front of it. Further, the hand follows the radius in this movement, and the dorsal aspect of both is directed to the front, and the thumb is turned inwards.

The dissector should analyse, as far as possible, in the part upon which he is engaged, the movements at the two radio-ulnar joints which produce these effects. At the same time it should be remembered that results obtained from a limb, in which the dissection has proceeded so far, are apt to be deceptive.

In the case of the superior radio-ulnar joint the movement is simple enough. The head of the radius merely rotates within the orbicular ligament, and accuracy of motion is obtained by the cup-like depression on the upper end of the radius, resting and moving upon the rounded capitellum of the humerus. But it should be remembered that the head of the radius does not fit accurately upon the capitellum in all positions of the elbow-joint. In extreme extension and extreme flexion of the elbow it is only partially in contact with it. Therefore the semi-flexed condition of the elbow-joint places the radius in the most favourable position for free and precise movement at the superior radio-ulnar joint.

At the inferior radio-ulnar joint the lower end of the radius revolves around the lower end of the ulna, and carries the hand with it. In this movement the triangular fibro-cartilage moves with the radius, and travels backwards on the lower end of the ulna in supination, and forwards in pronation.

But the question may be asked, Does the ulna move during pronation and supination? When the elbow-joint is extended to its fullest extent the ulna remains almost immovable. When, however, pronation and

supination are conducted in the semi-flexed limb, the ulna does move. A small degree of lateral movement at the elbow-joint is allowed, and the lower end of the ulna during pronation is carried slightly backwards and outwards, and in the reverse direction during supination.

The muscles which are chiefly concerned in producing *supination* of the forearm are—the biceps, the supinator longus, and the supinator brevis. The biceps, from its insertion into the back part of the radial tubercle, is placed in a very favourable position, in so far as its supinating action is concerned. The muscles which act as *pronators* of the limb are—the pronator radii teres, the pronator quadratus, and, to a certain extent, the flexor carpi radialis. The pronator radii teres, from its insertion into the point of maximum outward curvature of radius, can exercise its pronating action to great advantage. The balance of power is in favour of the supinators, and this is due to the preponderating influence of the biceps.

Dissection.—The ulna should be sawn through at the junction of its middle and lower thirds, and the interosseous membrane where it binds the lower portion of the bone to the radius divided in a downward direction. By drawing the lower fragment of the ulna inwards and opening the membrana sacciformis, the upper surface of the triangular fibro-cartilage of the wrist will be displayed and its attachments more fully appreciated.

Carpal Joints.—In studying the articulations of the carpal bones we recognize—

1. A joint between the pisiform and cuneiform bones.
2. Two joints between the bones of the first row, viz. the scaphoid, semilunar, and cuneiform.
3. Three joints between the bones of the second row, viz. the trapezium, trapezoid, os magnum, and unciform.
4. A transverse carpal joint between the two rows of carpal bones.

The pisiform joint is distinct and separate. All the others present a single joint-cavity. Further, this common cavity is continued into the articulations between the metacarpal bones of the four fingers and the carpus, and also into the intermetacarpal articulations.

Pisiform Joint.—The pisiform bone is fixed to the cuneiform by a capsular ligament which surrounds the joint. There is a separate synovial membrane for this articulation.

The dissector has previously noted that the tendon of the flexor carpi ulnaris is inserted into the upper aspect of the pisiform bone. The capsular ligament by itself would be insufficient to withstand the strain to which this muscle subjects the articulation. Certain accessory ligaments are therefore provided, which anchor the pisiform firmly in its place. These consist of two strong ligamentous bands which pass from its lower surface to the hook of the unciform bone, and to the base of the fifth metacarpal bone. Additional security is frequently given by bands which connect it with the bases of the fourth and third metacarpal bones.

First Row of Carpal Bones.—*Two dorsal*, *two palmar*, and *two interosseous* ligaments pass transversely from the semilunar to the scaphoid and cuneiform bones which lie on either side of it.

The two interosseous ligaments are composed of short stout fibres which pass between the non-articular portions of the opposed surfaces of the three bones. They are readily seen from above, where they complete the superior carpal surface of the radio-carpal joint.

The Second Row of Carpal Bones.—*Three palmar*, *three dorsal*, and *three interosseous* ligaments pass transversely between the adjacent bones.

The interosseous ligament between the os magnum and unciform is very powerful and strong; that between the os magnum and trapezoid is weak, and sometimes absent. At the present moment the interosseous ligaments are hidden from view, but they can be studied when the transverse carpal joint between the two rows of bones is opened.

Transverse Carpal Joint (between the two rows of carpal bones).—*Two lateral ligaments*, which pass between the scaphoid and trapezium on the outer side, and the cuneiform and unciform bones on the inner side, together with a series of *palmar* and *dorsal bands*, and *one interosseous ligament*, connect the two rows of carpal bones together.

The *palmar ligaments* show a tendency to converge upon the os magnum, whilst the *dorsal ligaments* are very irregular. The *interosseous ligament* is placed between the os magnum and scaphoid bones, but is not always present.

Articular Surfaces.—To display the articular surfaces and interosseous ligaments of the second row it is necessary to open the transverse carpal joint. This can be done by dividing the two lateral and the dorsal ligaments. The interosseous ligament between the scaphoid and os magnum, if present, will now come into view, and it must be cut, to allow the thorough separation of the two rows of carpal bones.

The os magnum and unciform form a high convexity, which fits into the concavity of the upper row, whilst the convex lower surface of the scaphoid is received into a concavity formed by the trapezium and trapezoid. The two opposing surfaces, therefore, are concavo-convex from side to side, and adapted the one to the other.

Movements at the Carpal Joints.—The movements at the carpal joints are complementary to those of the radio-carpal joint, and tend greatly to increase its range. Between the individual bones of each row the movement is of a gliding character, and very limited. At the transverse carpal joint forward and backward movement (flexion and extension) is alone allowed.

By the multiplicity of joints in this part of the limb, strength and elasticity is contributed to the wrist.

Dissection.—The interosseous muscles should now be removed from the metacarpal bones. At the same time

the flexor tendons and lumbrical muscles may be detached from the fingers. The extensor tendons, however, should be left in position on the dorsal surface of the metacarpo-phalangeal and interphalangeal joints. The ligaments which connect the carpus and metacarpus, and those which pass between the bases of the four inner metacarpal bones, should be cleaned and defined.

Intermetacarpal Joints.—The four metacarpal bones of the fingers articulate with each other by their basal or proximal extremities, and are united together by strong ligaments. The metacarpal bone of the thumb stands aloof from its neighbours, and enjoys a much greater freedom of movement.

The ligaments which bind the four inner metacarpal bones to each other are—

1. A series of *palmar* and *dorsal* bands which pass transversely, and connect their basal extremities.
2. *Three* stout *interosseous ligaments*, which occupy the intervals between the basal ends of the bones.
3. The *transverse metacarpal ligament*, which connects the heads or distal extremities of the bones (p. 152). This ligament has been removed in the dissection of the interosseous muscles.

The *interosseous ligaments* cannot be seen at present, but can be studied later on by separating the bases of the metacarpal bones from each other.

Carpo-metacarpal Joints.—The *metacarpal bone of the thumb* articulates with the trapezium by a joint which is quite distinct from the other carpo-metacarpal articulations. A *capsular ligament* surrounds the joint, and is sufficiently lax to allow a very considerable range of movement. On the dorsal and outer aspects of the articulation it is specially thickened. It encloses a separate synovial membrane.

The *four inner metacarpal bones* are connected to the carpus by *palmar* and *dorsal ligaments*, and by *one interosseous ligament.*

Each of these metacarpal bones, with the exception of the fifth, possesses, as a rule, two dorsal ligaments and one palmar ligament. The articulation of the fifth metacarpal bone is also closed on the inner side by ligamentous fibres.

The *interosseous ligament* springs from the contiguous lower margins of the os magnum and unciform, and passes to the inner side of the base of the third metacarpal bone. To display this ligament, divide the bands which connect the bases of the third and fourth metacarpal bones, and sever the dorsal ligaments which bind the two inner metacarpal bones to the carpus. The metacarpal bones thus set free can then be forcibly bent forward, when the ligament in question will come into view.

Synovial Membranes of the Carpal, Carpo-metacarpal, and Intermetacarpal Joints.—The pisiform joint, and the carpo-metacarpal joint of the thumb, possess each a separate synovial membrane. The other carpal, and carpo-metacarpal, and also the intermetacarpal articulations present one continuous joint cavity, and possess a single synovial membrane. This complicated and extensive synovial membrane may be seen to pass upwards in the intervals between the three bones of the first row (scaphoid, semilunar, and cuneiform) as far as the interosseous ligaments. It lines the under surfaces of these, and is excluded by them from the radio-carpal joint. In a downward direction it may be traced between the four bones of the second row to the carpo-metacarpal joints of the four fingers, and from these it finds its way into the three intermetacarpal articulations.

In some cases the interosseous ligament which connects the base of the third metacarpal to the os magnum and unciform shuts off the articulation of the unciform with

the two inner metacarpal bones, and the innermost inter-metacarpal articulation from the general joint cavity. In such cases a separate synovial membrane is provided for these articulations.

Articular Surfaces.—To display the articular surfaces of the carpo-metacarpal articulations, the metacarpus should be detached from the carpus. The base of the metacarpal bone of the index will then be seen to be hollowed out for the reception of the trapezoid. On the outer side it likewise articulates with the trapezium, and on the inner side with the os magnum. The base of the third metacarpal rests on the os magnum alone. The base of the metacarpal bone of the ring finger rests upon the unciform, but also articulates slightly with the os magnum. The fifth metacarpal bone articulates with the unciform.

The interosseous ligaments between the carpal bones of the second row, and also between the bases of the four inner metacarpal bones, can now be demonstrated by carrying the knife between the bones, and dividing the ligaments.

Movements of the Metacarpal Bones.—The opposed saddle-shaped surfaces of the trapezium and thumb-metacarpal allow very free movement at this joint. Thus the metacarpal bone of the thumb can be moved—(1) backwards and outwards (extension); (2) forwards and inwards (flexion); (3) inwards towards the index finger (adduction); (4) outwards (abduction); (5) inwards across the palm towards the little finger (opposition). The muscles which operate upon the thumb are—(1) the three extensors (extensor ossis metacarpi, extensor primi internodii, and the extensor secundi internodii), producing *extension*; (2) the flexor brevis pollicis and the opponens pollicis, producing *flexion* and *opposition*, two movements which are similar in character; (3) the abductor pollicis, which produces *abduction*; (4) and the two adductors (adductor obliquus and the adductor transversus), which give rise to *adduction*.

The metacarpal bones of the middle and index fingers possess very little power of independent movement. The metacarpal bone of the ring finger, and more especially the metacarpal bone of the little

finger, are not so tightly bound to the carpus. In clenching the fist they both move forwards. The metacarpal bone of the little finger is provided with an opponens muscle, and has a feeble power of advancing forwards and outwards to meet the thumb.

Metacarpo-phalangeal Articulations. — The slightly cupped base of the first phalanx of each digit articulates with the rounded head of the corresponding metacarpal bone, and is held in position by three ligaments, viz. a palmar and two lateral.

The *palmar ligament* is a dense fibrous plate placed on the fore aspect of the joint. It is firmly attached to the base of the phalanx, but only slightly connected with the metacarpal bone. Occupying the interval between the two lateral ligaments, it is united to both by its margins, so that the three ligaments are more or less directly continuous.

The palmar ligament also exhibits a close connection with the transverse metacarpal ligament which stretches transversely across the heads of the metacarpal bones, and its palmar surface is grooved for the flexor tendons as they proceed downwards over the joint. Further, the flexor sheath which bridges over the tendons is fixed to its borders.

The *lateral ligaments* are placed one on either side of the joint. They are strong, thick, and short bands, which are attached on the one hand to the tubercle and depression on the lateral aspect of the head of the metacarpal bone, and on the other to the base of the phalanx.

The extensor tendon should now be raised from the dorsal aspect of the joint. By this proceeding the joint is opened, and a demonstration is afforded of the fact, that the metacarpo-phalangeal joints are destitute of dorsal ligaments.

A *synovial membrane* lines the deep surfaces of the ligaments in each joint, and also the deep surface of the extensor tendon, as it passes over the articulation and takes the place of a dorsal ligament.

Movements at the Metacarpo-phalangeal Joints.—The movements of the first phalanx at these joints are—(*a*) *flexion*, or forward movement; (*b*) *extension*, or backward movement; (*c*) *abduction;* and (*d*) *adduction.*

During flexion of the fingers, the first phalanx travels forwards with the thick palmar ligament upon the head of the metacarpal bone. The *interosseous* and *lumbrical* muscles are chiefly instrumental in producing this movement.

The first phalanges of the fingers in the movement of extension can only be carried backwards to a very slight degree beyond the line of the metacarpal bones. The *extensor communis* and the *special extensors of the index and little finger* are the muscles which operate in this case.

Abduction and adduction are movements of the first phalanx away from and towards a line prolonged downwards through the middle finger, and are seen when the fingers are spread out and again drawn together. The *abductor minimi digiti* and the *dorsal interosseous* muscles act as abductors of the fingers at these joints, whilst the *palmar interosseous* muscles operate as adductors of the little, ring, and index fingers. In the case of the middle digit, the *second and third dorsal interosseous muscles* act alternately as abductors and as adductors. In connection with the movements of abduction and adduction it should be noticed that in the extended position of the fingers they are very free; but if flexion be induced, the power of separating the fingers becomes more and more restricted, until it becomes absolutely lost when the hand is closed. An examination of the lateral ligaments will afford the explanation of this. These 'are attached far back on the metacarpal bones, so as to be much nearer to their inferior ends than to their palmar aspects' (Cleland). Consequently, whilst they are comparatively lax in the extended position of the fingers, the further flexion advances the tighter they become, and in this way interfere with the lateral movements of the first phalanges.

The first phalanx of the thumb has only a limited range of movement at the metacarpo-phalangeal joint.

Interphalangeal Joints.—The ligaments connecting the phalanges are arranged upon a plan identical with that already described in connection with the metacarpo-phalangeal joint. This should not be made an excuse however to slur them over.

Movements.—The nature of the articular surfaces only admits of flexion and extension. Flexion of the second phalanges of the fingers

is brought about by the flexor sublimis, and of the ungual phalanges by the flexor profundus. Extension of the phalanges at the interphalangeal joints is largely produced by the interosseous and lumbrical muscles acting through the extensor tendons, into which they are inserted. These muscles therefore, whilst they flex the first phalanx at the metacarpo-phalangeal joints, extend the second and ungual phalanges at the interphalangeal joints.

In the case of the thumb, the long flexor and the extensor secundi internodii pollicis operate at the interphalangeal joint.

THORAX.

The dissection of the thorax is commenced on the *eleventh* day* after the subject has been placed in the Rooms. By this time the upper limbs have been detached from the trunk.

In form the thorax resembles a truncated cone. In front and behind it is flattened; but laterally it is full and rounded. During life the movements of the thoracic walls produce alterations in the capacity of the chest cavity, and play an essential part in the function of respiration.

In front, the thoracic cavity is bounded by the sternum and costal cartilages; behind, it is bounded by the twelve dorsal vertebræ and the intervening cartilaginous discs, together with the portions of the ribs which extend outwards from the vertebral column as far as the angles. Laterally, the shafts of the ribs from their angles behind to their anterior extremities in front limit the thoracic cavity. These parts constitute the frame-work of the thorax, and can be studied on the skeleton.

The anterior wall of the thorax is shorter than the posterior wall. Thus, during expiration, the upper margin of the manubrium sterni is placed opposite the disc between the second and third dorsal vertebræ, whilst the lower end of the body of the sternum corresponds in level with the middle point of the body of the ninth dorsal vertebra. The dorsal vertebræ project forwards into the cavity of the thorax, and greatly diminish its antero-posterior diameter in the mesial plane; but on either side

* Saturdays and Sundays are not counted.

of the vertebral column, owing to the backward sweep of the posterior portions of the ribs, a deep hollow is formed for the reception of the lung.

The superior aperture, or *inlet of the thorax*, is a narrow opening which is bounded by the first dorsal vertebra, the first pair of costal arches, and the manubrium sterni. The plane of this opening is very oblique; it slopes from behind forwards and downwards. Through the inlet of the thorax enter the windpipe, gullet, the pneumogastric nerves, the gangliated cords of the sympathetic, and the great veins which carry blood towards the heart from the head and neck and the superior extremities; whilst through the same opening egress is given to the thoracic duct and to the arteries which convey blood to the neck, head, and upper limbs.

The base or dependent part of the thorax is very wide, and is sometimes called the *outlet*. In front it is bounded by the ensiform cartilage, and behind by the twelfth dorsal vertebra. Between these points the lower margin of the thorax presents a curved outline. Starting from the sternum, it proceeds downwards, outwards, and backwards along the cartilages of the seventh, eighth, ninth, and tenth ribs. At the tip of the eleventh rib the direction of the lower margin of the thorax changes, and it proceeds upwards, backwards, and inwards along the twelfth rib to the vertebral column.

Attached to the lower margin of the thorax is the *diaphragm*, a muscular partition which intervenes between the cavity of the chest above and the cavity of the abdomen below. It is highly vaulted or dome-shaped, and projects upwards so as to form a convex floor for the thorax, and a concave roof for the abdomen. The upward projection of the diaphragm greatly diminishes the vertical depth of the thoracic cavity.

But the diaphragm does not form an unbroken partition. It presents three large openings, by means of which structures pass to and from the thorax, viz.—(1) for the

aorta, thoracic duct, and vena azygos major; (2) for the œsophagus and pneumogastric nerves; (3) for the inferior vena cava. Besides these there are other smaller apertures which will be mentioned later on.

THORACIC WALL.

Two days at least should be devoted to the dissection of the thoracic wall.

In addition to the osseous and cartilaginous framework, the walls of the chest are built up partly by muscles, and partly by membranes, and in connection with these there are numerous nerves and blood-vessels.

Muscles, . . .	External intercostals. Internal intercostals. Triangularis sterni.
Membranes, . .	Anterior intercostal membrane. Posterior intercostal membrane. Pleural membrane (parietal part).
Nerves and Arteries,	Intercostal nerves. Aortic intercostal arteries. Superior intercostal artery. Internal mammary artery.

Portions of certain of the muscles of the upper limb and of the abdominal wall will be noticed attached to the thoracic wall. From before backwards the dissector will meet with the *pectoralis major*, the *pectoralis minor*, and the *serratus magnus*, whilst towards the lower margin of the chest he will recognise the *rectus abdominis* in front, and the *obliquus externus* and *latissimus dorsi* upon its lateral aspect. The rounded tendon of the *subclavius* may also be observed taking origin from the first costal arch, and posteriorly to this the *scalenus posticus* extends downwards to its insertion into the second rib. With the single exception of the scalenus posticus, these muscles should be removed so as to lay bare the costal arches and the inter-

costal muscles. In detaching the serratus magnus be careful not to injure the *lateral cutaneous* nerves which make their appearance in the intervals between its digitations. The *anterior cutaneous* nerves and *perforating* branches of the internal mammary artery must also be preserved ; they pierce the origin of the pectoralis major in the intervals between the costal cartilages, and close to the margin of the sternum.

Intercostal Muscles.—These are the muscles which occupy the eleven intercostal spaces on each side. In each space there are two strata of muscular fibres—a superficial and a deep. The superficial layer of muscular fibres is called the *external intercostal* muscle, and the deep layer the *internal intercostal* muscle.

The *external intercostal* muscles are already exposed, and very little cleaning is necessary to bring out their connections. Observe that entering into their constitution there is a large admixture of tendinous fibres, and that these, as well as the muscular fibres, are directed from above, obliquely downwards and forwards from the lower border of the rib above to the upper border of the rib below. They do not extend further forwards in the various spaces than a point corresponding to the union of the bony with the cartilaginous parts of the costal arches. In some cases, especially in the upper spaces, they do not reach so far. Here the muscular fibres stop short, but the tendinous fibres are prolonged onwards to the sternum in the form of a membrane, which may be called the *anterior intercostal membrane.* The external intercostal muscles of the two lower spaces are exceptions to this rule. They extend forwards to the extremities of the spaces. Posteriorly the muscles pass backwards as far as the tubercles of the ribs, but this is a point which can only be satisfactorily demonstrated after the thorax has been opened into.

To bring the *internal intercostal* muscles into view it is necessary to reflect the external intercostal muscles, and

also the anterior intercostal membranes. Divide them along the upper borders of the ribs which bound the spaces inferiorly, and throw them upwards. This dissection should be performed in each intercostal space, and, in effecting it, care must be taken of the intercostal arteries which lie between the two muscular strata.

The *internal intercostal* muscles thus laid bare will be seen to be similar in their constitution to the external muscles. The fibres, however, run in the opposite direction—viz. from above, obliquely downwards and backwards. Superiorly they are attached to the inner surface of the upper rib, immediately above the subcostal groove; inferiorly they are attached upon the inner surface of the lower rib, close to the upper margin. The internal intercostal muscles are prolonged forwards to the sternum. Posteriorly they reach backwards to the angles of the ribs, from which to the spine the muscles are replaced by a series of thin membranes—the *posterior intercostal membranes*—which will be seen after the thorax has been opened. If the internal oblique muscle of the abdomen has not been removed, the dissector should note that the anterior fibres of the two lowest internal intercostal muscles become continuous with the fibres of that muscle.

Intercostal Nerves.—The intercostal nerves are altogether out of sight in the present stage of the dissection. They are hidden by the lower borders of the ribs which bound the intercostal spaces superiorly. By gently pulling upon their lateral cutaneous branches they can be drawn downwards, and they are then seen to lie between the two muscular strata as far forward as a point midway between the spine and sternum. Here they disappear from view by sinking into the substance of the internal intercostal muscles, amidst the fibres of which they may be traced as far as the anterior extremities of the bony ribs. They now reach the deep surface of these muscles and are carried inwards, first upon the pleura, and then upon the triangu-

laris sterni muscle. Lastly, they cross the internal mammary artery, and come forwards at the side of the sternum as the *anterior cutaneous nerves* of the pectoral region (p. 21). Before it reaches the surface each nerve pierces—(*a*) the internal intercostal muscle, (*b*) the anterior intercostal membrane, (*c*) the origin of the pectoralis major, and (*d*) the deep fascia.

But this description only holds good for the upper five intercostal nerves. The *lower six nerves*, on leaving the anterior ends of the intercostal spaces, pass forwards into

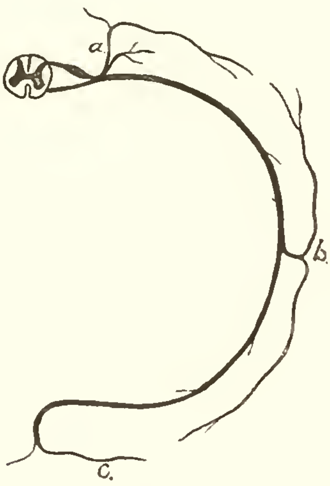

FIG. 30.

Diagram of a Dorsal Spinal Nerve.

a Posterior primary branch; *b* Lateral cutaneous branch of the anterior primary division; *c* Anterior cutaneous.

the abdominal wall between the internal oblique and transversalis muscles, where they have already been displayed by the dissector of the abdomen.

The intercostal nerves, as they traverse the thoracic wall, give off—(*a*) the lateral cutaneous branches; and (*b*) twigs to the intercostal muscles and triangularis sterni. Their terminal branches constitute the anterior cutaneous

nerves. The lateral cutaneous branches come off midway between the spine and the sternum, and, piercing the external intercostal muscles, appear in the intervals between the digitations of the serratus magnus (p. 21).

It is not necessary to make a dissection of the intercostal nerves in more than two or three of the spaces.

Intercostal Vessels.—The intercostal arteries should be dissected in those spaces in which the nerves have not been traced, and in which, therefore, the internal intercostal muscles are still entire. It is only in a well-injected subject that a satisfactory view of these vessels can be obtained. In each intercostal space *one* artery is found passing from *behind forwards*, and *two*, the *anterior intercostal* arteries, running from *before backwards*.

In the upper two spaces the vessels which run from behind forwards are derived from the *superior intercostal* branch of the subclavian artery ; in the nine lower spaces they spring directly from the aorta, and are called the *aortic intercostals*.

The *anterior intercostal* arteries of the upper six spaces proceed directly from the internal mammary, whilst in the case of the lower spaces they come from the outer of its terminal branches—viz. the musculo-phrenic.

The intercostal vessels are distributed between the two muscular strata. From the angles of the ribs onwards to a point midway between the spine and sternum, the *aortic intercostals* lie under shelter of the lower margins of the ribs which bound the spaces superiorly, and at a higher level than the corresponding nerves. Here each divides into two branches, and these pass forwards in relation to the upper and lower margins of the intercostal space. They give off small branches which accompany the lateral cutaneous nerves. The *superior intercostal* arteries are disposed in a similar manner. The *anterior intercostal* arteries are two in number for each space. At their origin they lie under cover of the internal intercostal muscles, but they

soon pierce these, and run onwards in relation to the upper and lower margins of the ribs bounding each space. They end by anastomosing with the aortic and superior intercostal arteries.

Dissection.—The dissector should next proceed to remove the intercostal muscles. This dissection must be carried out with more than usual care, because immediately subjacent to the internal intercostal muscles, over the greater extent of the chest wall, is the delicate pleural membrane lining the inner surface of the costal arches. *Upon no account detach this membrane from the deep surface of the ribs*, and take the greatest care to preserve it intact during this dissection.

On the front of the chest, the *internal mammary artery* and the *triangularis sterni muscle* will be seen to intervene between the pleura and the costal cartilages. The internal mammary artery, with its two companion veins, will be seen descending in a vertical direction, about half an inch from the outer margin of the sternum. Clean these vessels carefully in the intervals between the costal cartilages, and note some small lymphatic glands which lie along the course of the vessels. As a rule, the artery ends by dividing into two terminal branches in the interval between the sixth and seventh rib-cartilages. Most likely this space will be so narrow, that a view of the bifurcation cannot be obtained. In this case pare away the edges of the cartilages over the artery, or if necessary remove the inner part of the sixth cartilage completely. The perforating branches of the internal mammary artery which accompany the anterior cutaneous nerves should be preserved.

The muscle upon which the internal mammary artery lies is the triangularis sterni. Endeavour to define its slips in the interval between the costal cartilages.

The Internal Mammary Artery arises in the root of the neck from the first part of the subclavian, and enters the

thorax, by passing downwards behind the inner end of the clavicle and the cartilage of the first rib. Accompanied by two veins, it descends to the interval between the sixth and seventh costal cartilages, where it ends by dividing into the *superior epigastric* and the *musculo-phrenic* branches. It runs parallel with the outer margin of the sternum, from which it is separated by an interval of about half an inch.

Placed *in front* of the internal mammary artery are the upper six costal cartilages, with the intervening intercostal muscles and anterior intercostal membranes. It is crossed by the intercostal nerves before they turn forwards to gain the surface. In the upper part of its course the artery is supported by the pleura, but lower down it rests upon the triangularis sterni which intervenes between it and the pleural sac.

In addition to its two terminal branches, a large number of small collateral twigs proceed from the internal mammary—

1. The anterior intercostal, . 2. The perforating, . .	to the thoracic parietes.
3. The comes nervi phrenici, 4. Mediastinal and thymic,	to the interior of the thorax.
5. Superior epigastric, . 6. Musculo-phrenic, . .	to the terminal branches.

The *anterior intercostal arteries* are supplied to the upper six intercostal intervals, and have already been dissected (p. 181). Two are given to each space, but frequently they arise by a common trunk.

The *perforating arteries* accompany the anterior cutaneous nerves, and reach the surface by piercing the internal intercostal muscles, the anterior intercostal membranes, and the pectoralis major muscle. One, or perhaps two, are given off in each intercostal space. And in the female two or three of the intermediate members of the series attain a special importance, inasmuch as they constitute the principal arteries of supply to the mammary gland.

The *superior epigastric artery* enters the sheath of the rectus muscle of the abdominal wall by passing downwards behind the seventh costal cartilage.

The *musculo-phrenic* turns outwards and downwards along the costal origin of the diaphragm and behind the rib-cartilages. Opposite the eighth costal cartilage it pierces the diaphragm and enters the abdomen. It gives off the *anterior intercostal arteries* to the lower intercostal spaces (p. 181).

The Triangularis Sterni is a thin muscular layer placed on the deep surface of the sternum and costal cartilages. It is continuous below with the transversalis muscle of the abdominal wall, and arises from the posterior surface of the ensiform cartilage, the lower part of the body of the sternum, and from the inner ends of the 5th, 6th, and 7th costal cartilages. From this origin its fibres radiate in an upward and outward direction, and separate into five slips, which are inserted into the deep surfaces and lower borders of the 2nd, 3rd, 4th, 5th, and 6th costal cartilages, close to their junction with the ribs.

In many cases the muscle is feebly developed, and does not show so wide connections as those which are described above. Upon the superficial aspect of the triangularis sterni are placed the internal mammary artery and the series of intercostal nerves.

It is only a partial view of the muscle which is obtained in the present dissection, but it is not advisable to remove the costal cartilages to expose it further, as this would very materially interfere with the subsequent display, in their proper relations, of other more important structures.

Dissection.—Towards the lower margin of the thorax the pleural sac is not prolonged downwards to the lowest limit of the recess between the diaphragm and the costal arches. Indeed, in the axillary line, it will be found to fall very considerably short of this. Consequently,

when the internal intercostal muscles are removed from this portion of the chest wall, the dissector will come

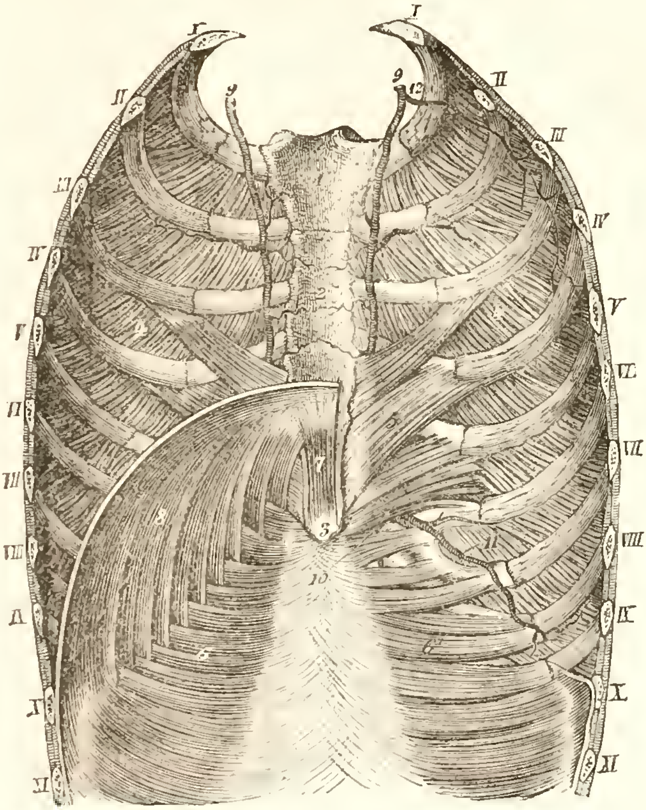

FIG. 31. (From Luschka.)

Posterior aspect of the Anterior Wall of the Thorax and Upper Part of the Abdomen.

1. Manubrium sterni.
2. Gladiolus.
3. Ensiform cartilage.
4. Internal intercostal muscle.
5. Triangularis sterni.
6. Transversalis abdominis.
7. Sternal origin of diaphragm.
8. Costal origin of diaphragm.
9. Internal mammary artery.
10. Superior epigastric artery.
11. Musculo-phrenic artery.
12. An occasional branch of the internal mammary.

down directly upon the diaphragm; and as the fibres of the diaphragm correspond somewhat in their direction with those of the internal intercostal muscles, it is no

uncommon occurrence for the student to remove them, and thus expose the peritoneum, under the impression that he has simply laid bare the pleura. When the dissection has been properly executed, a strong fascia will be observed to pass from the surface of the diaphragm on to the surface of the costal pleura so as to hold it in position. Preserve this for further examination.

THORACIC CAVITY.

The arrangement of the two pleural sacs within the thoracic cavity must now engage the attention of the student; but in order that the relations of these may be understood, it is absolutely necessary that the dissector should have some preliminary knowledge of the thoracic viscera. The principal viscera of the chest are the lungs and the heart. The two *lungs* occupy by far the greatest part of the space, and lie one upon either side of the mesial plane. The *heart* is placed between the lungs, and projects more into the left than the right side of the cavity. It is completely enveloped by a loose conical fibro-serous sac called the *pericardium*, which is attached by its base to the upper surface of the diaphragm. Each lung is connected with the base of the heart by several large vessels which pierce the pericardium, and these, with the corresponding division of the windpipe, passing to the lung, constitute the *pulmonary root* or *pedicle*. The lungs are free within the thorax except where they are attached by their roots.

Pleural Sacs.—The pleural sacs are two in number, one in each side of the chest cavity. They are serous sacs, and therefore closed. Each pleural bag is so disposed that it not only lines the recess in which the lung lies, but is also reflected over the lung so as to give to it an external covering, which is intimately connected with the pulmonary substance. We recognize, therefore, in connection with each pleura a lining or *parietal* part, and an investing

or *visceral* part. It must be clearly understood, however, that these terms are merely applied to indicate different portions of one continuous membrane.

The dissection which has already been made shows the pleura lining the deep surface of the costal arches and internal intercostal muscles. This portion is called the *pleura costalis*. The manner in which the pleura of each side is reflected backwards from the posterior aspect of the sternum must now be investigated. This entails a somewhat complicated dissection.

The sternum must be divided with the saw into four portions by three separate cuts, viz.—(1) a transverse section through the manubrium sterni, on a line with the *lower* margins of the first pair of costal cartilages; (2) a transverse cut through the lower part of the body of the sternum, in the interval between the *fifth* and *sixth* costal cartilages; (3) an oblique section, beginning below at the inferior transverse cut, close to the left margin of the sternum, and carried upwards to the middle of the superior transverse cut. By the last section the central portion of the sternum is divided into two lateral pieces, to each of which four costal arches are attached.*

In making these sections through the sternum, the saw should only be used until the thick periosteum on the back of the bone is reached. This can then be divided cautiously with the knife. Of course the internal mammary vessels must be preserved, and the greatest care must be taken not to separate the parietal pleura at any point from the deep surface of the thoracic wall.

The two lateral portions of the central piece of the sternum should now be gently separated from each other, and, on looking between them, the parietal pleura of each side will be seen leaving the posterior surface of the sternum, and passing backwards to reach the pericardium. But the pericardium is not in view, except perhaps to a

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* This dissection was devised by Sir William Turner.

very small extent below, because the two pleural membranes, where they make this reflection, are in contact. Introduce the finger between the two pleural sacs, and pass it upwards and downwards through the loose areolar tissue which holds them together. The pericardium is in this way exposed, and a striking demonstration is obtained

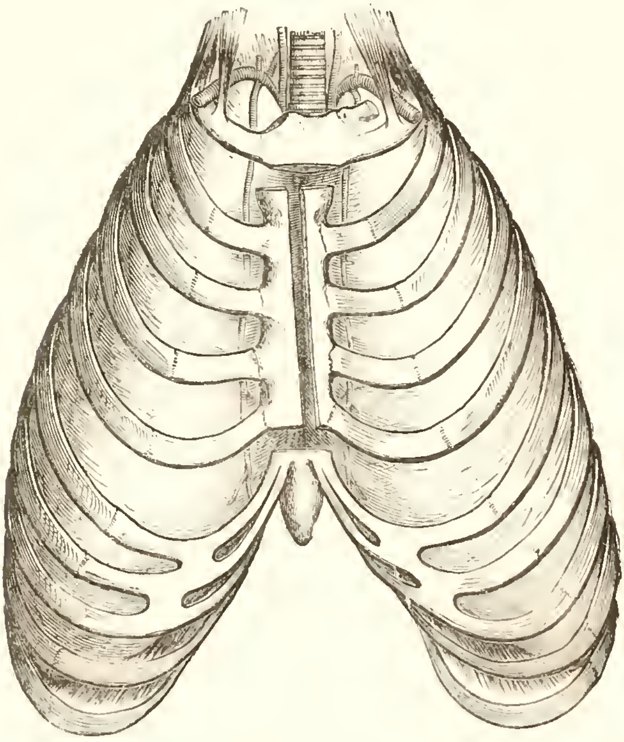

FIG. 32.

Dissection of the Anterior Mediastinum.

of a space which is termed the *anterior mediastinum*. *In front* this space is bounded by the posterior surface of the body of the sternum, and usually also by the inner ends of the fifth, sixth, and seventh costal cartilages of the left side, clothed by the left triangularis sterni muscle; *behind*, by the pericardium; and *upon each side*,

by the pleura as it passes from the back of the sternum to the front of the pericardium. In its upper part the space can hardly be said to exist, seeing that the pleural sacs are in contact, but below, the left pleura falls somewhat short of the right pleura, and an interval is apparent. The only *contents* to be noticed in the anterior mediastinum are, in its lower part, a few small lymphatic glands and some loose areolar tissue, in which ramify lymphatic vessels and some minute arterial twigs from the internal mammary artery.

Having now ascertained the relations of the pleura to the chest wall, proceed to the study of its connections within the thorax. For this purpose the parietal pleura must be separated from the ribs as far forward as the cartilages. This can best be done by gently insinuating the forefinger between each of the ribs and the pleura, and then running it backwards and forwards. Upon no account detach the pleura from the cartilages. Next divide with the knife the *second*, *third*, *fourth*, *fifth*, and *sixth* costal arches at the junction of the osseous with the cartilaginous portions, and remove these ribs by snipping through them with the bone pliers as far back as possible. The sternum and cartilages, to which the pleura is still adherent, must be left in position until the arrangement of the membrane has been thoroughly investigated.

The greater part of the costal pleura now lies flaccid upon the surface of the lung. Make a vertical incision through it, midway between the spine and sternum, from the level of the second costal arch down as far as the seventh rib. From each extremity of this vertical cut carry an incision forwards for two or three inches.

A considerable piece of the parietal pleura can now be thrown forwards like a door, and the interior of the pleural sac is exposed. The inner surface of the membrane, if healthy, presents an appearance which is characteristic of all serous membranes. It is smooth, polished,

and glistening, and is moistened by a small amount of serous fluid. It is thus admirably adapted to allow the movements of the lung during respiration to take place with the smallest possible degree of friction. When the surface of the membrane becomes roughened by inflammatory exudation, the so-called "friction sounds" of pleurisy become evident when the ear is applied to the chest.

Introduce the hand into the pleural sac, and explore its extent and connections. First carry it inwards behind the costal cartilages. Its passage across the mesial plane

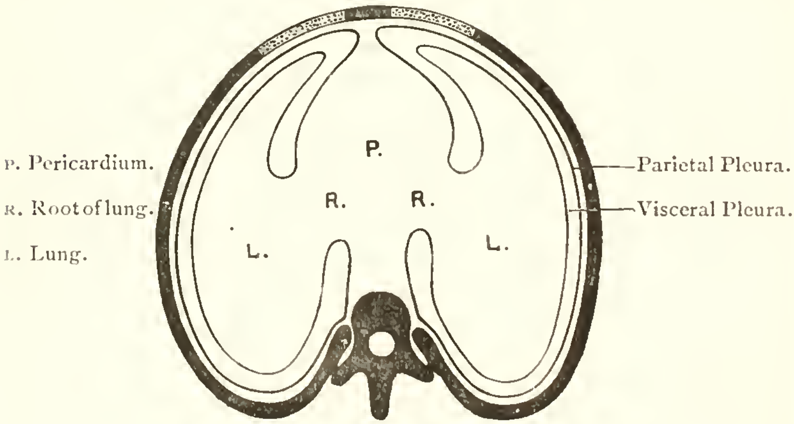

FIG. 33.
Diagram of the two Pleural Sacs.

of the body is effectually barred by the reflection of the pleural membrane from the back of the sternum to the front of the pericardium. Above the level of the pericardium it passes right back to the vertebral column, and then proceeds outwards on the ribs. Upon the lateral aspect of the pericardium it can be traced backwards towards the spine, and here it must be studied from two points of view, viz.—(1) at the level of the root of the lung, and (2) below the root of the lung.

At the level of the pulmonary root, the pleura is carried outwards, so as not only to envelope this, but also the

entire lung. The smooth glistening surface of the organ is due to the pleural investment which it thus acquires. This then is the *visceral pleura,* and it should be noticed that it is very much finer and thinner than the parietal pleura. Further, it is inseparably attached to the pulmonary substance. Behind the root of the lung the pleura is prolonged backwards upon the pericardium, and on the left side over the descending thoracic aorta to the bodies of the vertebræ. On the right side it passes directly from the pericardium to the bodies of the vertebræ. This can be seen by tilting forwards the thick posterior border of the lung. From the vertebræ, the pleura passes outwards upon the deep surfaces of the ribs.

Below the level of the root of the lung, the pleura can be traced backwards upon the pericardium to the spine, from which it is conducted outwards upon the ribs. But it does not pass backwards uninterruptedly.

The same two layers which envelope the pulmonary root are prolonged outwards in opposition with each other. Meeting the inner surface of the lung, they separate to enclose the lower portion of this organ. The fold of pleura which is thus formed is called the *ligamentum latum pulmonis,* and it can be brought into view by enlarging the opening in the pleural sac, and drawing the basal portion of the lung outwards and backwards. It will then be seen in the form of a triangular fold of pleural membrane, which extends from the lower border of the pulmonary root along the inner surface of the lung to the diaphragm.

The dissector has now traced the continuity of the pleural sac in the transverse direction. He has observed that it lines the deep surface of the costal arches, and is reflected backwards in the form of an intra-thoracic partition from the back of the sternum to the spine. This partition is called the *mediastinal pleura,* and it is uninterrupted, except where it is pushed outwards over the lung and lung-root in the form of an investment. But the continuity of the membrane in a longitudinal direction

must also be established. This inquiry will render clear its relations in the upper and lower parts of the thoraci ccavity.

In the upper part of the chest cavity, the pleura will be observed to extend upwards through the thoracic inlet into the root of the neck, and to form in this locality a dome-shaped roof for each side of the chest (Fig. 32, p. 188). This portion of the pleura is called the *cervical pleura*, and it passes upwards above the level of the anterior part of the first costal arch for a distance of from one to two inches. The height to which it rises varies considerably in different individuals. The subclavian artery arches over and lies in a groove in this cul-de-sac, and the scalenus anticus muscle is in relation to its outer surface. Further, the cervical pleura is supported and strengthened by an aponeurotic expansion (*Sibson's fascia*) which is spread over it, and receives attachment to the inner concave margin of the first rib. This fascia is derived from a small muscular slip which takes origin from the transverse process of the seventh cervical vertebra. It may be regarded as a derivative from the scalene group of muscles.

In the lower part of the thorax the parietal pleura is reflected from the inner surface of the chest wall on to the upper surface of the diaphragm, and is carried inwards upon this towards the pericardium. This portion of the membrane is termed the *diaphragmatic pleura*.

The Lines of Pleural Reflection.—The two pleural sacs are not shaped alike. The right pleura is shorter and wider than the left, and consequently the lines along which the two membranes are reflected from the sternum and costal cartilages backwards towards the pericardium, and also from the chest wall on to the diaphragm, differ somewhat on the two sides.

Behind the manubrium sterni the two pleural sacs are separated from each other by an angular interval, but near the upper end of the gladiolus they come together, and proceed downwards in close contact, and slightly to the left

of the mesial plane, as far as the sternal end of the fourth costal cartilage. Not only are they in contact, but in transverse sections through the chest, it will be seen that the left pleural sac in this position slightly overlaps the right pleural sac (Fig. 34). At the level of the attachment of the fourth costal cartilage to the sternum the two sacs part company. The left pleura deviates outwards, whilst the right pleura is continued downwards in a straight line behind the sternum to the back of the ensiform cartilage. Here it turns sharply outwards, and running obliquely downwards and backwards upon the

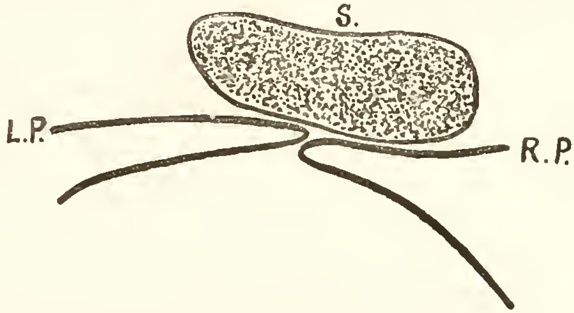

FIG. 34.
Tracing from a Transverse Section through the frozen Chest, at the level of the junction of the third Costal Cartilages with the Sternum.
S. Sternum; L.P. Left Pleura; R.P. Right Pleura.

deep surface of the seventh costal cartilage, is reflected from this on to the upper surface of the diaphragm. Following the line of diaphragmatic reflection on the right side, it will be seen to continue in a downward and backward direction across the bony extremity of the eighth rib, across the ninth rib, until it reaches *in the axillary line* the ninth intercostal space, or, perhaps, the upper margin of the tenth rib. Crossing the tenth rib, it runs inwards and backwards along the eleventh rib, and reaches the spine at the level of the neck of the twelfth rib.

Trace now the line along which the left pleura is reflected from the chest-wall below the level of the sternal

end of the fourth costal cartilage. At this point it retires in an outward direction from the right pleura, and descends at a variable distance from it, so as to leave a small triangular portion of the pericardium uncovered by pleura, and in direct contact with the anterior chest-wall. This area is very variable in its extent, but the accompanying diagram expresses what is generally considered to be the average condition.*

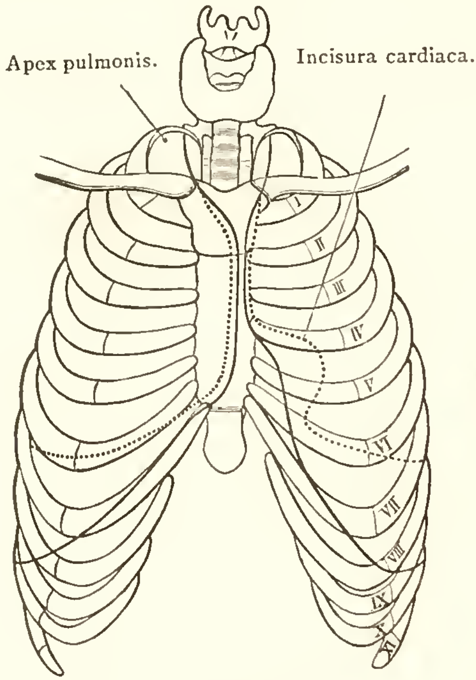

FIG. 35. (From Gegenbaur.)

The Pleural Reflection on each side is represented by a solid black line. The outline of the Lung is indicated by a dotted line.

* It is right to mention, however, that the deviation of the left pleura does not, as a rule, take place to such an extent as one might be led to expect from an inspection of this diagram. Dr. Brooks, at the request of the author, made a large number of careful observations on this point, and these all went to show that the deviation represented above is somewhat exaggerated, and that the bare area of the pericardium is not so extensive.

Proceeding downwards behind the fourth intercostal space, the fifth costal cartilage, the fifth intercostal space, and the sixth costal cartilage close to the margin of the sternum, the line of left pleural reflection will then be seen to incline obliquely outwards and downwards behind the seventh costal cartilage, and across the eighth, ninth, and tenth ribs, until it reaches a point midway between the spine and the sternum. Throughout, the line of the diaphragmatic reflection of the left pleura is placed at a slightly lower level than the corresponding line on the right side. The left pleura is therefore deeper than the right pleura, and, *in the axillary line*, it reaches the lower margin of the tenth rib.* From this point, as on the opposite side, the lower limit of the left pleura extends backwards along the eleventh rib to the spine, which it reaches at the level of the vertebral extremity of the twelfth rib.

On neither side then does the pleura reach to the lowest limit of the recess between the diaphragm and the chest-wall. This has already been noted in the dissection of the intercostal spaces, and a strong fascia has been observed to pass from the uncovered part of the surface of the diaphragm, and from the costal cartilages to the surface of the costal pleura, so as to hold it firmly in place. It may be compared with *Sibson's fascia*, which covers the cervical pleura, but is more strongly marked and more tendinous in character. It may be termed the *phrenico-pleural fascia*.

Mediastinum.—The *mediastinum* or *mediastinal space* is the name which is given to the interval which is left between the two pleural sacs. It is within this space that

* According to Luschka the right pleura in the axillary line only reaches downwards as far as the lower border of the ninth rib; whilst the left pleura in the same line reaches the lower border of the tenth rib. The deepest part of the pleural sac is not in the axillary line, as stated by some authors, but behind, where it is reflected on to the diaphragm along the 11th and 12th ribs.

by far the greater part of the dissection of the thorax has to be conducted, and, consequently, it is important that the student should acquire an accurate conception of its extent and connections. We have noted that the mediastinal portion of the pleura extends backwards from the front wall of the thorax on either side of the mesial plane, in the form of an intra-thoracic partition. This forms the lateral boundary of the space, whilst in front it is bounded by the sternum, and behind by the vertebral column. But it is customary to subdivide in an arbitrary manner the mediastinal space into four portions, termed, respectively, superior, anterior, middle, and posterior, according to the relation which they present to the pericardium.

Superior Mediastinum.—This is the part of the general mediastinal space which lies above the level of the pericardium. Its *boundaries* are the following:—*In front*, the manubrium sterni, to the posterior aspect of which are attached the lower ends of the sterno-hyoid and sterno-thyoid muscles; *behind*, the upper four dorsal vertebræ with the longus colli muscles; *below*, an imaginary and oblique plane extending from the lower border of the manubrium sterni backwards and upwards to the lower border of the fourth dorsal vertebra; and *laterally* the mediastinal pleura as it extends on each side from the back of the sternum to the vertebral column.

Figures 49 and 51 (pp. 239 and 242) are reproduced from tracings of two sections through the superior mediastinum at different levels. Figure 51 represents a section through its upper part, and figure 49 a section through its lower part at the level of the fourth dorsal vertebra. The boundaries, form, and contents of the space, are clearly seen.

Within the superior mediastinum are placed—(1) the transverse part of the aortic arch, and the three great vessels which spring from it; (2) the innominate veins and the superior vena cava in its upper part; (3) the trachea, gullet, and thoracic duct; (4) the vagus, phrenic,

left recurrent laryngeal and cardiac nerves; (5) the thymus gland. The relative positions of these can be studied, in the meantime, in figs. 49 and 51: afterwards they will be displayed in the course of dissection.

The Middle Mediastinum is the wide middle part of the space which contains the pericardium, and lies below the superior mediastinum. In addition to the pericardium and its contents, the middle mediastinum contains the phrenic nerves and their arteriæ comites.

The Anterior Mediastinum is that portion of the interpleural space which lies between the pericardium behind and the body of the sternum in front. It has already been examined (p. 188).

The Posterior Mediastinum is situated between the pericardium and the bodies of the vertebræ. It will be studied later on.

Dissection.—The central portion of the sternum, with the attached costal cartilages, may now be removed and laid aside until a suitable opportunity arises for the study of the chondro-sternal joints. Carefully strip the mediastinal pleura from the side of the pericardium. This will bring into view the *phrenic nerve* and the slender *arteria comes nervi phrenici*, a branch of the internal mammary which accompanies it upon the side of the pericardial sac. During this dissection the minute *mediastinal* and *thymic branches* of the internal mammary artery will be brought into view.

The Lungs.—The lungs are two soft, spongy organs placed one on either side of the mediastinal space. When the thorax is opened they collapse to about one-third of their original bulk, and it is difficult for the student to realise their proper dimensions and shape. *With the consent* of the dissector of the head and neck, the nozzle of the bellows may be introduced into the cervical part of the

trachea so as to inflate the lungs with air. A truer conception of these organs will thus be obtained, and a demonstration will be afforded of their high elasticity, and of their connection with the trachea or windpipe.

When healthy and sound, the lungs lie free within the cavity of the chest, and are only attached by their roots. It is rare, however, that a healthy lung is seen in the dissecting rooms. Adhesions between the visceral and parietal portions of the pleura due to pleurisy are generally present.

In its natural condition, before the chest is opened, each lung is conical in form, and presents for examination an apex, a base, an outer and an inner surface, and an anterior and a posterior border. The *apex of the lung* is blunt and rounded, and rises above the level of the first costal arch, protruding upwards through the thoracic inlet into the root of the neck. The subclavian artery arches over the apex of the lung, and a groove corresponding to the vessel may be recognized upon it. The cervical pleura intervenes between them. The *base of the lung* presents a semilunar outline, and is adapted to the upper surface of the diaphragm. Consequently, it is deeply hollowed out; and as the right cupola of the diaphragm ascends higher than the left, the basal concavity of the right lung is deeper than that of the left lung. Laterally, and behind, the base of each lung is limited by a thin sharp margin, which passes downwards in the narrow pleural recess (*sinus phrenico-costalis*) between the diaphragm and chest wall. This margin extends much lower down behind and at the outer side than in front.

But the bases of the lungs establish important relations with the viscera which occupy the costal zone of the abdominal cavity—the diaphragm alone intervening. Thus the base of the right lung rests upon the right lobe of the liver; whilst the base of the left lung is in relation to the left lobe of the liver, the stomach, the spleen, and in some cases to the splenic flexure of the colon (Fig. 37, p. 206).

The *outer surface of the lung* is very extensive and is full and convex. It is in relation to the parietal pleura, as it clothes the ribs and intercostal muscles, and it bears the impress of the costal arches. The *inner surface* presents a much smaller area than the outer surface, and is deeply concave in adaptation to the pericardium upon which it fits. As the heart projects more into the left side of the chest, the concavity on the inner side of the left lung is more marked than it is in the right lung. Upon this surface is the *hilum*, or the place of attachment of the root. It is situated somewhat nearer the apex than the base, and also nearer the posterior than the anterior border of the lung. Through the hilum enter the arteries, nerves, and bronchus, whilst through the same slit the veins and lymphatics emerge.

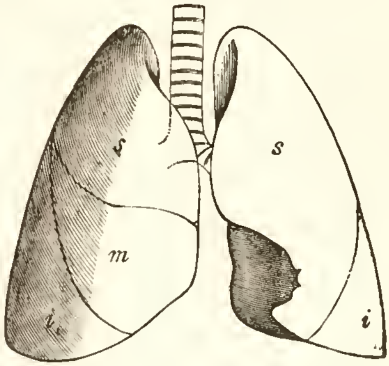

FIG. 30. (From Gegenbaur.)
The Lungs.

s. Superior lobe; *m*. Middle lobe; *i*. Inferior lobe.

The two borders of the lung stand in marked contrast to each other. The *anterior border* is short, thin, and sharp, and extends forwards and inwards in front of the pericardium into the narrow pleural recess behind the sternum and costal cartilages (*sinus costo-mediastinalis*). The *posterior border of the lung* is thick, long, and rounded, and occupies the deep hollow of the thoracic cavity which is placed on each side of the spine.

During respiration the two surfaces, the posterior border and the lower surface of the base and the apex of the lung always remain in close apposition with the walls of the cavity in which the organ lies. The sharp margin around the base rises and falls in the sinus phrenico-costalis, but it is doubtful if it ever even in the deepest inspiration reaches the lowest limit of this recess. The anterior sharp margins of the lungs approach and retreat to a slight degree from each other in

front of the pericardium in the sinus costo-mediastinales. In full inspiration, behind the upper two pieces of the gladiolus of the sternum, they are only separated from each other by the two layers of mediastinal pleura, and as a general rule the left lung slightly overlaps in this locality the right lung. (Fig. 34.)

But there are some points in which the two lungs differ from each other: (1) The right lung is slightly larger than the left, in the proportion of 11 to 10. (2) The right lung is shorter and wider than the left lung. This difference is due to the great bulk of the right lobe of the liver, which elevates the right cupola of the diaphragm to a higher level than the left cupola, and likewise to the heart and pericardium, projecting more to the left than the right, and thus diminishing the width of the left lung. (3) The anterior sharp margin of the right lung is more or less straight; the corresponding margin of the left lung presents, in its lower part, a marked angular deficiency (*incisura cardiaca*) for the reception of the apex of the heart and the pericardium. (4) The right lung is subdivided into three lobes, and the left lung into two.

Lobes of the Lungs.—The left lung is divided into two lobes, by a long oblique deep fissure which penetrates its substance to within a short distance of the root. This fissure begins above at the posterior border, about three inches below the apex, and about the level of the vertebral end of the third rib, and is continued in a somewhat spiral direction downwards and forwards to the anterior end of the base of the lung. The upper lobe of the lung lies above and in front of this cleft. It is conical in form with an oblique base. The apex and the whole of the anterior border belong to it. The lower lobe, somewhat quadrangular, lies below and behind the fissure, and belonging to it we recognize the entire base and the greater part of the thick posterior border. It is therefore the more bulky of the two.

In the *right lung* a similar fissure is present, but in addition to this a second fissure maps off from the lower

end of the upper lobe, a third or intermediate lobe. This second cleft begins at the posterior border of the lung in the oblique fissure, and proceeds horizontally forwards on the outer surface to the anterior border. The middle or intermediate lobe of the right lung is triangular or wedge-shaped in outline.

Root of the Lung.—This is the term which is applied to a number of structures which enter the lung at the hilum or slit upon its inner concave surface. These structures are held together by an investment of pleura, and thus constitute a pedicle which retains the lung in its place.

The pleura should be carefully stripped from around the root of the lung; but, before undertaking the dissection of the parts which compose the root, the relation which it bears to neighbouring parts should be determined.

In front there are—(1) A delicate plexus of nerves, the anterior pulmonary plexus; and (2) the phrenic nerve with the arteria comes nervi phrenici. *Behind*, the pneumogastric nerve breaks up into the posterior pulmonary plexus; whilst, *inferiorly*, there is the ligamentum latum pulmonis. These are the relations which are common to the root of the lung upon each side of the body, but there are others which are peculiar to each side.

On the *right side*—(1) The vena azygos major, as it passes forwards to join the superior vena cava, is in relation to the upper border of the pulmonary root; (2) the superior vena cava, in the lower part of its course, lies in front of the pulmonary root.

On the *left side*, the arch of the aorta arches over the root of the lung, and the descending thoracic aorta passes down behind it.

Now proceed to dissect out the constituent parts of the root of the lung. The most important structures which enter into its formation are—(1) *the two pulmonary veins*;

(2) *the pulmonary artery;* (3) *the bronchus.* But, in addition to these, there are one or two small *bronchial arteries* and *veins*, the *pulmonary nerves*, and the *pulmonary lymphatic vessels.* These are bound together by some loose areolar tissue, and the whole is invested by pleura.

The *pulmonary nerves* are derived from the anterior and posterior pulmonary plexuses. The *anterior pulmonary plexus* is composed of two or three delicate filaments, which come from the pneumogastric nerve before it reaches the posterior aspect of the pulmonary root. These join with the sympathetic twigs on the wall of the pulmonary artery. The deep cardiac plexus gives twigs to the anterior pulmonary plexus on both sides of the body. But the plexus of the left side is larger than that of the right side, because it receives a few filaments from the superficial cardiac plexus. It is only under the most favourable circumstances that a good dissection of these nerves can be made.

The *posterior pulmonary plexus* is easily dissected. To get at it, the lung must be thrown well forwards over the pericardium, and the pleura stripped from the posterior surface of the pulmonary root. The pneumogastric nerve should then be secured and followed downwards. On the left side it will be found crossing the aortic arch; on the right side it lies by the side of the trachea. The posterior pulmonary plexus is formed by the entire trunk of the pneumogastric nerve, breaking up into a flattened network immediately under cover of the pleura upon the posterior aspect of the root of the lung. Several minute twigs from the upper thoracic ganglia of the sympathetic enter this plexus.* From both the anterior and posterior pulmonary plexuses fine twigs are prolonged into the lung along the divisions of the bronchi. The posterior branches, however, are much larger than the anterior.

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* The posterior pulmonary plexuses of opposite sides are connected by some strong branches, which cross the mesial plane in front of and behind the oesophagus.

The *bronchial arteries*, one or two in number on each side, are the proper nutrient vessels of the lung. They are placed on the posterior aspect of the root of the lung, and have, no doubt, been exposed in the dissection of the posterior pulmonary plexus. As a general rule they lie in close contact with the back of the bronchus and follow it into the lung.

The *pulmonary vessels* and the *bronchus* should now be separated from each other with the handle of the knife, and their relative positions in the root of the lung studied.

This dissection should be made, not only in front, but also behind, so that the parts may be thoroughly isolated and separated from each other. Hardened and blackened bronchial glands sometimes render the proceeding a difficult one. These must be removed.

The *pulmonary veins* are placed *most anteriorly* and the *bronchus most posteriorly*, whilst the *pulmonary artery* is *intermediate* in position. When examined in respect to their relations from above downwards, the two sides of the body differ from each other. On both sides *the veins* occupy the *lowest* level. On the *right side* the bronchus is highest and the artery intermediate, whereas on the *left side* the artery is highest and the bronchus intermediate in position. The different position of the bronchus in the roots of the lungs is not due to any difference in the direction of the main stems or trunks of the tubes, but to the fact that on the right side a branch arises from the bronchus close to its origin, and proceeds almost horizontally outwards to the upper lobe of the lung. This division, which is not represented in the left side, lies above the level of the pulmonary artery, and in consequence receives the name of the *eparterial bronchus* (Aeby). The other branches of the right bronchus, and all the branches of the left bronchus, lie below the level of the main trunk of the corresponding pulmonary artery, and are termed *hyparterial bronchi*.

The relation of parts in the roots of the two lungs may be shortly expressed thus :—

FROM BEFORE BACKWARDS.

Both sides, ...	Veins. Artery. Bronchus.

FROM ABOVE DOWNWARDS.

Left side, . .	Artery. Bronchus. Veins.	*Right side,* . .	Bronchus. Artery. Veins.

Phrenic Nerve.—This is a long nerve which arises in the neck from the cervical plexus, and traverses the entire length of the mediastinal space to reach the diaphragm. It has already been exposed upon the lateral aspect of the pericardium in front of the root of the lung. Follow it upwards and downwards.

The phrenic nerve enters the chest cavity through the thoracic inlet, and as it does so it passes behind the subclavian vein, and crosses obliquely the internal mammary artery in a direction from without inwards. It now proceeds downwards through the superior mediastinum into the middle mediastinum. Here it is applied to the side of the pericardium in front of the root of the lung, and is covered by the mediastinal pleura. Finally reaching the diaphragm, the nerve breaks up into several branches which pierce its substance and spread out on its under surface.

But the two phrenic nerves of opposite sides present certain differences. They differ (1) in length; and (2) in certain of their relations.

The left phrenic is the longer of the two nerves, and this is due, partly, to the greater projection of the heart and pericardium to the left side, and partly to the fact, that the left cupola of the diaphragm which it enters does not rise so high as the right cupola. The difference in relationship is the following :—(1) The left phrenic nerve, as it traverses the superior mediastinum, crosses

in front of the aortic arch; (2) the right phrenic nerve lies in relation to the right side of the right innominate vein and the superior vena cava; (3) one or more of the terminal branches of the right nerve pass through the opening in the diaphragm for the inferior cava.*

The *branches* of the phrenic are chiefly destined for the supply of the diaphragm, but in its course through the middle mediastinum it gives a few fine filaments to the pericardium and the pleura.

The small branch of the internal mammary artery which accompanies the phrenic nerve, the *arteria comes nervi phrenici*, may be traced in a well-injected subject to the forepart of the diaphragm. It takes origin high up in the thorax, and gives branches to the pericardium.

Superficial Cardiac Plexus.—The best plan to adopt in making a dissection of these delicate nerve filaments is to begin by securing the two cardiac nerves which enter the plexus from above. These are—(1) the cardiac branch from the superior cervical ganglion of the sympathetic of the *left* side; (2) the inferior cardiac branch of the *left* pneumogastric nerve. Look for both of these nerves upon the aortic arch. They will be found crossing it to the left of the phrenic nerve, between it and the pneumogastric nerve. The cardiac branch from the left pneumogastric nerve is the smaller of the two, and as a general rule it lies nearer the phrenic nerve than the other.

The superficial cardiac plexus into which these nerves may be traced lies in the concavity of the aortic arch, and upon the bifurcation of the pulmonary artery. At the point of junction of the nerves the minute *ganglion of Wrisberg* may be discovered. The manner in which this plexus is distributed to the heart will be afterwards noted: in the

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* It is frequently stated that the right phrenic nerve lies deeper in the chest than the left phrenic. This is not the case, as anyone may ascertain for himself by the examination of a series of transverse sections through the frozen thoracic cavity (*vide* Figs. 49 and 50).

meantime observe that it gives some fine offsets to the left anterior pulmonary plexus.

The Pericardium should now be cleaned. In removing the loose areolar tissue from its anterior surface two ligamentous bands which connect it to the posterior aspect of the sternum will be observed. Of these, one—the *inferior sterno-pericardiac ligament*—binds it to the ensiform cartilage, whilst the other—the *superior sterno-*

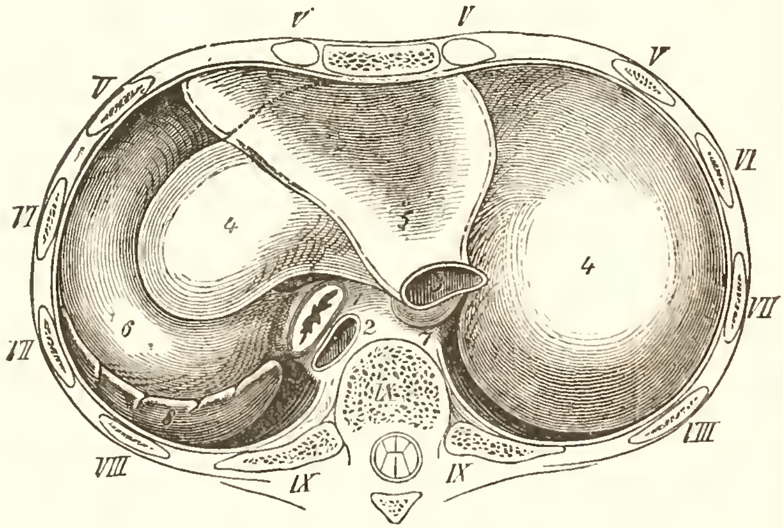

FIG. 37. (From Braune.)

Dissection to show the Abdominal Viscera which lie in relation to the Under Surface of the Diaphragm.

1. Œsophagus.
2. Aorta.
3. Vena cava inferior.
4. Liver.
5. Pericardium.
6. Stomach.
7. Lobulus Spigelii of the liver.
8. Spleen.

The dotted line marks off the part of the Pericardium in relation to the Stomach.

pericardiac ligament—connects it with the manubrium sterni, and comes into relation with the pretracheal layer of the deep cervical fascia. The upper surface of the diaphragm should be carefully cleaned at the same time, in order that its relation to the pericardium may be studied.

The *pericardium* is a fibro-serous sac which loosely envelopes the heart. It is placed in the middle subdivision of the mediastinal space, and presents a somewhat conical form. By its *base* it rests chiefly upon the central tendinous part of the diaphragm, but beyond the limits of this it encroaches, to some extent, upon the muscular portion. More especially is this the case on the left side. Except at one point, no difficulty will be experienced in separating the pericardium from the diaphragm. The two are simply bound together by some intervening areolar tissue. Towards the middle line, however, it will be found over a small area to be inseparably blended with the central tendon. It is important to recognize the abdominal viscera which stand in relation to the base of the pericardium. It is placed, for the greater part of its extent, over the upper surface of the liver, the diaphragm alone intervening; but in front, a small part corresponding to the apex of the heart projects beyond the area of the liver and comes to lie over the stomach (Fig. 37). The *upper narrow part* of the pericardium will be noticed to close upon certain of the great vessels that issue from the base of the heart. *Upon each side* the pericardium is adapted to the concave inner surface of the lung. It is clothed by the mediastinal pleura, and has in relation to it the phrenic nerve and the arteria comes nervi phrenici. *In front* very important relations have to be studied. It lies behind the sternum and costal cartilages, and is for the most part separated from these by the two pleural sacs, and by the anterior thin margins of the lungs. Below the level of the sternal end of the fourth costal cartilage, however, owing to the left pleura retreating somewhat to the left, a small area of the anterior surface of the pericardium, as a general rule, comes into direct relation with the chest wall. The extent*

* The importance of recognizing this bare area of the pericardium will be understood when it is remembered that it is here that the surgeon taps the cavity of the sac when distended with fluid.

of this area, as we have already seen, is very variable. *Behind*, the pericardium forms the anterior wall of the posterior mediastinum, and is in relation to the contents of this space. Its relation to the œsophagus is especially intimate.

When the pericardium is denuded of the loose areolar tissue which surrounds it and binds it to adjacent structures, the strong dense character of the fibrous membrane which forms its *outer layer* will be seen. This fibrous layer is pierced by the various vessels which pass to and from the heart, and is prolonged upon the walls of these vessels in the form of tubular investments which gradually become lost upon their coats. The only vessel which fails to receive such a prolongation is the inferior vena cava, and this is due to the fact, that this vein pierces the pericardium where it rests on the diaphragm, and can, therefore, hardly be said to have any intra-thoracic course outside the pericardium.

The pericardium may be opened by means of a crucial incision, viz.—(1) a longitudinal incision along the middle line of the body from the point where it blends with the sheath of the aorta downwards to the diaphragm; (2) a transverse cut, extending from the middle of the root of one lung to a similar point on the opposite side. The *serous internal layer* of the pericardium is now brought under the notice of the student. This layer lines the entire inner surface of the fibrous pericardium, and is reflected from this, upon the vessels which pierce the fibrous layer, on to the surface of the heart. It gives a smooth, polished appearance to the heart and to the interior of the pericardial sac. The lining part of the serous layer is termed the *parietal portion;* the investing portion which covers the heart is called the *visceral part* or *the epicardium*. The great vessels in connection with the heart also receive more or less complete coverings from the serous layer. The two arteries, viz. the pulmonary artery and the aorta, are completely surrounded

by a single tubular sheath. This investment only leaves uncovered the surfaces of these vessels, which are in apposition with each other. This can readily be demonstrated by passing the forefinger behind them, when it will be seen that they are not attached to the posterior wall of the pericardium. The entire length of the pulmonary artery and the first or ascending portion of the aortic arch are enclosed within the fibrous sac of the pericardium. In the case of the veins, the covering which they receive from the serous pericardium is not so complete. They are covered in front and on each side, whilst posteriorly they are bare and in contact with the fibrous layer of the sac. The superior vena cava, which lies immediately to the right of the ascending part of the aorta, is a good example of this. Its lower half is enclosed within the fibrous sac, but only two-thirds of its circumference has a serous covering. The inferior vena cava, which pierces the base of the pericardium and at once opens into the right auricle of the heart, receives a very small investment.

When the apex of the heart is drawn forwards and upwards, a deep, blind recess of the serous pericardium will be seen, passing upwards behind it, between the pulmonary veins of opposite sides.

Lastly, separate the left pulmonary artery from the upper of the two left pulmonary veins, as they lie within the fibrous pericardium. Stretching across the interval between them will be seen a prominent fold of the serous layer. This is the '*vestigial fold of Marshall*.' It contains between its two layers a minute fibrous band, the remnant of the left superior vena cava of the embryo.

Remains of the Thymus.—In the adult, the *thymus gland*, which is such a conspicuous object in the superior mediastinum of the fœtus and young child, is only represented by some condensed tissue of a brownish colour, placed above the level of the aortic arch, and in front of the innominate and left common carotid arteries as they

spring from the arch. A few *thymic branches* from the internal mammary artery enter the wasted remains of the gland, and some small veins pass from it and join the subjacent left innominate venous trunk.

Dissection.—Remove the thymus, and dissect out the two innominate veins and the superior vena cava. The left innominate vein will be seen crossing the superior mediastinum from left to right. The short right innominate vein is placed in the upper and right part of the superior mediastinum. The union of these two trunks forms the vena cava superior. The tributaries which enter these veins must also be secured. One, the left superior intercostal vein, ascends in front of the aortic arch to reach the left innominate.

Innominate Veins.—The *innominate vein* of each side is formed behind the sternal end of the clavicle by the union of the subclavian and internal jugular veins. Behind the lower part of the junction of the first costal cartilage of the right side with the sternum, they unite to form the superior vena cava.

The *right innominate vein* is short. It is not more than one inch in length, and it has a nearly vertical course. Its outer surface is covered with pleura and is in relation to the phrenic nerve. The upper part of the innominate artery lies to its inner side.

The *left innominate vein* is much longer than the right vein, and has an oblique course from the left downwards, and to the right. It is placed behind the manubrium sterni and the remains of the thymus gland, and crosses the three great arteries which spring from the aortic arch.

The innominate vein of each side receives the following tributaries :—

1. The vertebral vein.
2. The inferior thyroid vein.
3. The vein which drains the blood from the first or highest intercostal space.
4. The internal mammary vein.

The left innominate in addition receives the left superior intercostal vein, and some small venous twigs from the thymus gland. The *left superior intercostal vein* is formed by the union of the veins from the second and third intercostal spaces. It crosses in front of the arch of the aorta, and is of interest in so far, that its upper part represents the upper pervious portion of the occluded left superior vena cava of the embryo.

The Vena Cava Superior should also be examined at this stage. It is formed behind the first costo-sternal junction of the right side by the union of the two innominate veins. From this it proceeds downwards, and it opens into the upper part of the right auricle of the heart at the level of the upper border of the third costal cartilage of the right side. It is three inches long, and shows very different relations in its upper and lower parts. In the *upper half* of its course it lies in the superior mediastinum (Fig. 39, p. 239). On the right side it is clothed by the mediastinal pleura, and has the phrenic nerve in contact with it; on the left side it is in relation to the innominate artery. In the *lower half* of its course it is enclosed within the fibrous pericardium, and is placed in the middle mediastinum. The serous pericardium covers it in front and laterally, whilst immediately to its left side is the ascending portion of the aortic arch. This portion of the superior vena cava lies in front of the pulmonary artery and the upper pulmonary vein of the right side.

The *vena azygos major* is the only large tributary which joins the superior vena cava. It comes forward above the right bronchus, and enters the vena cava immediately above the point where it pierces the pericardium. Minute *pericardiac* and *mediastinal* veins also pour their blood into it.

The *inferior vena cava* is a larger vessel than the superior vein of the same name. It enters the thorax by piercing the central tendon of the diaphragm. It can hardly be said to have any course within the thorax, seeing that it

immediately passes through the base of the pericardium, and opens into the lower and back part of the right auricle of the heart.

The Heart and its Vessels.—The heart is a hollow organ with muscular walls, somewhat conical in shape, and about the size of the clenched fist. It is placed obliquely within the middle mediastinum, so that its basal portion is directed upwards, backwards, and to the right, whilst its pointed apex looks downwards,

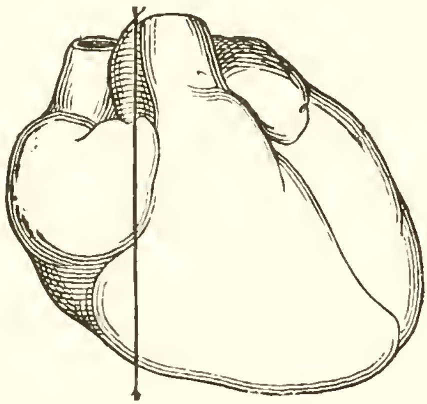

FIG. 38. (From Braune.)

The Vertical Line drawn through the Heart represents the Mesial Plane.

forwards, and to the left. But it is also placed unsymmetrically within the chest cavity. In other words it projects more to the left than to the right, and in cases where the frozen body is divided accurately in the mesial plane, it is found that about one-third of the organ is in the right, and about two-thirds in the left half of the thoracic cavity.

The **general relations** of the organ should now be examined. The *base* is placed in front of the middle portion of the dorsal segment of the vertebral column. Four dorsal vertebræ lie above it, and four below it, whilst the intermediate four (viz. the 5th, 6th, 7th and 8th) lie behind

it. The *apex* approaches the anterior wall of the thorax, and in life will be felt beating in the fifth intercostal space of the left side, one and a half inches below the nipple, and three and a half inches from the middle line. The *posterior surface*, which is flattened, and looks more downwards than backwards, rests upon the diaphragm—the floor of the pericardium alone intervening. Immediately below the cardiac area of the diaphragm is the upper surface of the liver, and in front and to the left a small piece of the stomach

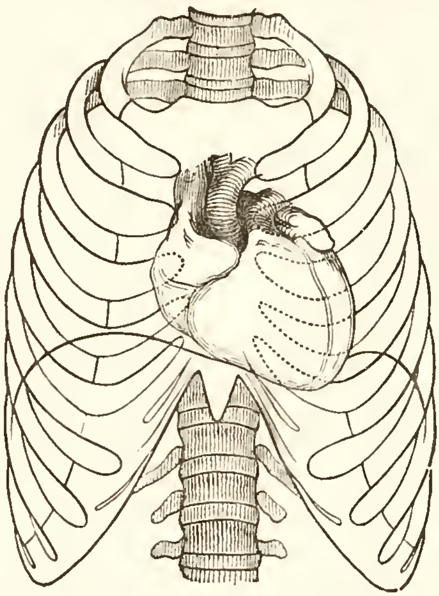

FIG. 39. (From Braune).

Diagram to show the position of the Heart in relation to the Anterior Chest wall.

(Fig. 37, p. 206). The *anterior surface* of the heart looks upwards as well as forwards, and lies behind the greater part of the gladiolus of the sternum and certain of the costal cartilages. On both sides the third, fourth, and fifth costal cartilages are in front of the heart, but as the chief bulk of the organ is situated to the left of the mesial plane, the left sixth costal cartilage is also in front of it: three costal cartilages on the right side, therefore, and four on the left

side are in relation to the anterior surface of the heart. The pleural sacs and the anterior thin margins of the lungs intervene between the heart and pericardium and the anterior wall of the thorax. A small portion of the pericardium in the lower part of the anterior mediastinum is in direct relation to the triangularis sterni muscle as it covers the deep surface of the sternum, and the inner extremities of the fifth and sixth costal cartilages of the left side. A wider area at the same level, owing to the incisura cardiaca in the anterior margin of the left lung, is uncovered by the lung. This area may be mapped out on the chest wall by drawing a vertical line along the middle line of the sternum, from the level of the inner extremities of the fourth costal cartilages to the lower end of the gladiolus, and by carrying two other lines, from the extremities of the first line, outwards so as to meet at a point over the apex beat of the heart. *On either side*, the heart and pericardium is supported by the mediastinal pleura and the inner surface of the lung.

The heart lies free within the sac formed by the pericardium, except where it is attached by the great vessels which are connected with its basal portion. Its position is influenced, to a certain extent, by the position of the body.

External Configuration of the Heart.—In studying the form and appearance of the heart, the dissector will find it advantageous to refer to an injected specimen. At the same time he should remember that such a specimen is apt to convey an erroneous impression, in so far, that during life the auricular and the ventricular chambers are never fully distended at the same time.

The interior of the heart is divided by an internal partition into a right and a left cavity. Further, each of these is still further subdivided into an upper *auricular* and a lower *ventricular* chamber, which communicate freely with each other through a wide auriculo-ventricular opening.

The right and the left cavities of the heart, however, are completely shut off from each other.

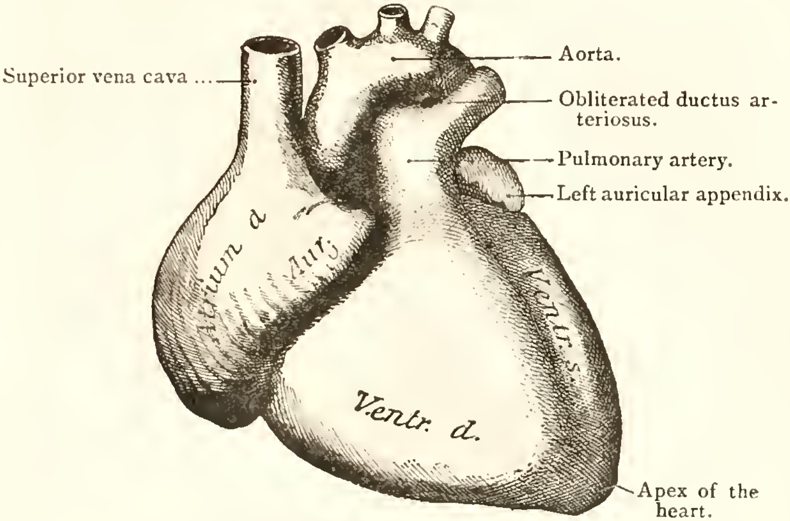

FIG. 40. (From Gegenbaur.)

Anterior aspect of the Heart.

Ventr. d. Right ventricle.
Ventr. s. Left ventricle.
Aur. Right auricular appendix.
Atrium d. Right atrium.

On the exterior of the heart there are markings which indicate this internal subdivision, and enable us to map out with the greatest accuracy the walls of the four chambers. Thus encircling the heart in transverse direction, nearer the base than the apex, is a deep furrow which is continuous all the way round, except in front, where it is interrupted by the root of the pulmonary artery. This is the *auriculo-ventricular* groove. It intervenes between the auricles which lie above it and the ventricles which are placed below it. In the undissected heart, with the epicardium in position, the depth of this furrow is somewhat obscured, from the fact that it lodges some large blood-vessels and a certain amount of fat.

The *auricular part* of the heart stands in marked contrast to the firm ventricular portion. Its walls are thin

and flaccid, and in the uninjected heart they are collapsed,

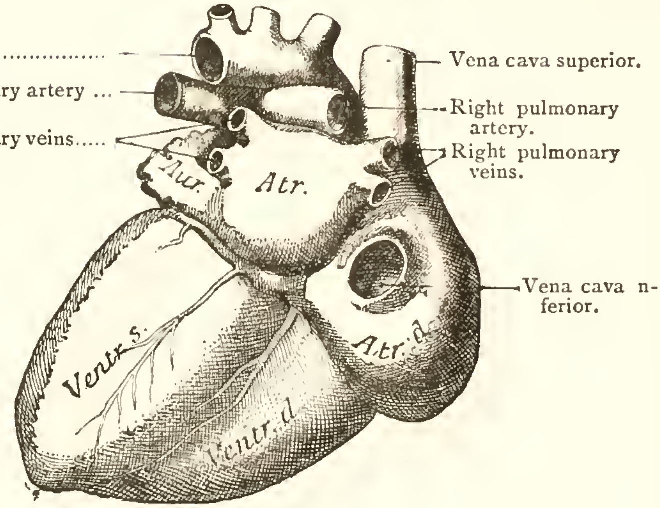

FIG. 41. (From Gegenbaur.)

Posterior Surface of the Heart.

Ventr. s. Left ventricle.
Ventr. d. Right ventricle,
Aur. Left auricular appendix.
Atr. Left atrium.
Atr. d. Right atrium.

so that it is difficult to realize the shape of this portion of

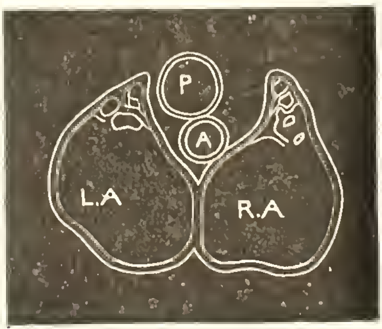

FIG. 42.

Transverse Section through the Auricular part of the Heart.

R.A. Right auricle ; L.A. Left auricle ; P. Pulmonary artery ; A. Aorta.

the organ. It is crescentic in form. The chief bulk of it

is placed behind, but it sends forwards two processes or cornua, termed the auricular appendices. A deep concavity or hollow is thus produced, in which lie the two great arterial trunks which spring from the ventricles, viz. the pulmonary artery in front and the aorta behind. The accompanying diagram, which represents a transverse section through the auricular portion of the heart, will serve to illustrate this point (Fig. 42).

On the posterior aspect of the auricular part of the heart a faintly marked groove extends in a vertical direction upwards from the auriculo-ventricular furrow (Fig. 41). This groove passes over the top of the auricular part, and then down in front of it. It corresponds to the internal attachment of the interauricular septum, which intervenes between the right and left auricular cavities, and therefore it is termed the *interauricular furrow*. The posterior capacious part of each auricle is somewhat quadrangular in shape, and is called the *atrium:* the prolongation forwards on each side of the great arterial trunks is termed the *auricular appendix*.

It should be noted that the left auricle forms a greater part of the posterior wall of the auricular portion of the heart than the right auricle. In other words, whilst the left auricle is placed almost completely behind, the right auricle comes, to a certain extent, to the front of the heart in connection with the right part of its base (Fig. 40).

The *ventricular part* of the heart is firm to the touch and possesses thick fleshy walls. It is very distinctly conical in form. Its apex corresponds to the apex of the heart; whilst its base is connected above with the two atria of the auricular part of the heart, and gives origin in front of these, and in the interval between the auricular appendices, to the two great arteries which conduct the blood from the ventricular chambers, viz. the pulmonary artery in front and the aorta behind.

In addition to the base and apex, the ventricular part of the heart presents two borders and two surfaces. The

right border is long and sharp, and is directed obliquely from right to left, from the base to the apex. It is called the *margo acutus*. The *left border* or *margo obtusus* is short, thick, and rounded.

The *anterior surface* of the ventricular part of the heart is full and convex, and is traversed by a groove which begins above at the auriculo-ventricular furrow immediately to the left of the origin of the pulmonary artery, and proceeds downwards towards the right sharp margin, which it reaches a little to the right of the apex. This groove is the *anterior interventricular furrow*, and it is placed much nearer to the left margin than to the right margin of the heart. The *posterior surface* is flattened and traversed by a similar groove, the *posterior interventricular furrow*. This joins the anterior groove below, round the right sharp margin of the heart, and is placed nearer the right than the left margin. These grooves are occupied by vessels and lodge a little fat. They indicate on the surface the anterior and posterior attachments of the interventricular septum, and therefore the extent of the walls of the two cavities. Roughly speaking, two-thirds of the anterior surface, the margo acutus, and rather more than one-third of the posterior surface, belong to the right ventricle; whilst one-third of the anterior surface, the margo obtusus, the apex of the heart, and rather less than two-thirds of the posterior surface, belong to the left ventricle. On the anterior surface of the heart a bulging of the wall of the right ventricle will be noticed in its upper and front part. This is termed the *infundibulum* or *conus arteriosus*. From its summit the pulmonary artery takes origin.

Cardiac Vessels and Nerves.—The vessels and nerves which are distributed to the substance of the heart may now be dissected. The main trunks occupy the furrows, and can be exposed by removing the epicardium and the soft fat which is generally placed around them. In a young subject, where the fat is scanty and the vessels

well injected, very little dissection is required. The nerves are exceedingly delicate and derived from the cardiac plexus. It is seldom that they can be satisfactorily displayed in an ordinary dissecting-room subject.

The **coronary arteries** are the nutrient arteries of the heart. They are two in number, and spring from the root of the aortic arch. It is here, therefore, that they must in the first instance be sought, by dissecting deeply in the auriculo-ventricular furrow. The *left coronary artery* springs from the left posterior sinus of Valsalva,* and proceeds outwards behind the pulmonary artery. It winds round the left side of the heart, and ends on its posterior aspect. Throughout its entire course it lies in the auriculo-ventricular furrow. It gives off numerous twigs to the left auricle and left ventricle, and one large branch will be observed to pass downwards in the anterior interventricular groove towards the apex of the heart.

The *right coronary artery* arises from the anterior sinus of Valsalva, and winds round the right margin of the heart in the auriculo-ventricular groove to reach its posterior aspect, where it ends near the termination of the artery of the left side. An arterial circle is thus formed, which embraces the base of the heart. The right coronary artery gives off two large branches. Of these, one passes downwards upon the right sharp margin of the heart, whilst the second and larger descends towards the apex in the posterior interventricular groove. It also supplies numerous smaller twigs to the right ventricle and right auricle.

Cardiac Veins.—Take hold of the heart by the apex and pull it upwards, so as to bring into view its posterior surface. In the groove between the left ventricle and left auricle—the *coronary sinus*—a short wide venous channel

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* The three sinuses of Valsalva are three bulgings of the wall of the aortic root. One is on the front, and the other two on the back of the vessel.

will be seen. Open it with the scissors along its whole length. By one extremity it opens into the right auricle, whilst by its other end it becomes continuous with the *great cardiac vein*, and the point of junction is marked by a valve of two segments. Several *posterior cardiac veins* from the posterior aspect of the ventricles also open into this sinus, and each orifice is guarded by a distinct valve. Of these, one much larger than the others, and sometimes called the *middle cardiac vein*, ascends in the posterior interventricular groove. The *right* or *small coronary vein* also joins the coronary sinus close to its termination. It occupies that part of the auriculo-ventricular furrow which, on the posterior surface of the heart, intervenes between the right auricle and right ventricle. Lastly, the *oblique vein of Marshall* from the back of the left auricle opens into the sinus close to the point where it joins the right auricle. The orifice of this vein is devoid of a valve. The oblique vein is very minute, and would not deserve special mention, were it not that it represents the lower pervious part of the obliterated left superior vena cava of the embryo.

The *great cardiac vein* begins upon the anterior aspect of the heart at the apex. It ascends in the anterior interventricular groove to the auriculo-ventricular furrow, in which it turns round the left margin of the heart to join the coronary sinus. On its way it is joined by numerous veins from the surface of both the ventricular and auricular parts of the heart.

The *anterior cardiac* veins will be seen on the front surface of the right ventricle. They open directly into the right auricle.

But in addition to these veins which appear upon the surface there are minute vessels in the substance of the heart—the *venæ Thebesii*—the orifices of which will be recognised, when the right auricle is opened, as the foramina Thebesii.

The cardiac veins, therefore, which drain the blood

from the heart, do not correspond with the arteries. The following table expresses the arrangement in a brief form:

Upon the surface of the heart.	Great cardiac vein. Posterior cardiac veins. Right cardiac vein. Oblique vein.	*Opening into* coronary sinus.
	Anterior cardiac veins.	*Opening into* right auricle.
In the substance of the heart.	Venæ Thebesii.	*Opening into* right auricle.

It is only in a heart which has been specially injected that all these veins can be seen. The general arrangement, however, can usually be studied in the course of an ordinary dissection. In certain cases, where the veins are empty and the fat on the surface of the heart scanty, they may be inflated with air by introducing a blow-pipe into some of the larger members of the series.

Cardiac Nerves.—The dissector should again turn to the minute nerves which form the superficial cardiac plexus. For the most part these are prolonged downwards, and being joined close to the heart by a considerable reinforcement from the deep cardiac plexus, form the *right coronary plexus* which comes into relation with the corresponding artery. The *left coronary plexus* which accompanies the artery of the same name is derived from the deep cardiac plexus. The nerves do not slavishly follow the arteries, they soon leave the vessels, and are ultimately lost in the substance of the heart. Here and there ganglia are developed in connection with them.

The chambers of the heart should now be opened in the order in which the blood flows through them.

Right Auricle.—Draw the heart well over to the left side of the body. Fig. 43 shows the direction in which the incisions through its walls must be made. Two cuts are required—(1) A vertical incision from the point at which the superior vena cava enters the auricle to the

point of entrance of the inferior vena cava. In making this incision, care must be taken not to injure the Eustachian valve—a fold of endocardium placed in front of the mouth of the inferior vena cava. (2) An oblique incision carried from about the middle of the first cut to the tip of the auricular appendix. The dark venous blood should

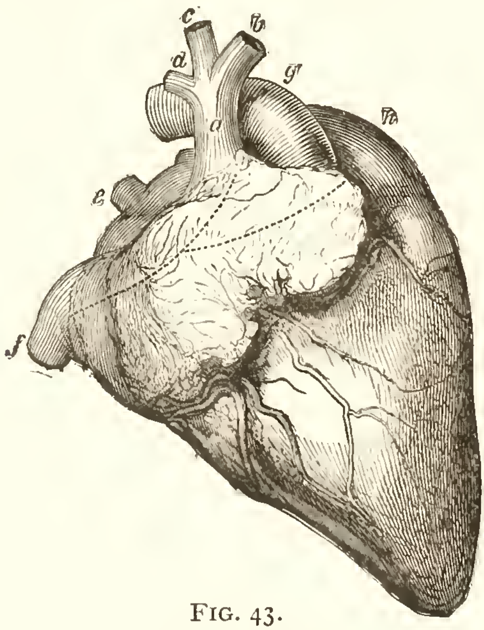

FIG. 43.

Diagram to show the manner in which the right auricle should be opened. The drawing is taken from an injected heart in the Edinburgh University. The dotted lines give the directions in which the two incisions should be made. *a*, Superior vena cava; *b*, Left innominate vein; *c*, Right innominate vein; *d*, Vena azygos major; *e*, One of the pulmonary veins; *f*, Inferior vena cava; *g*, Aortic arch; *h*, Pulmonary artery.

now be washed away from the interior of the auricle with a sponge.

The internal surface of the cavity presents a smooth glossy appearance, due to its endocardial lining. In the auricular appendix the wall is raised into a series of closely applied parallel ridges called the *musculi pectinati*, from their resemblance to the teeth of a comb. These ridges are also present on the anterior wall of the auricle.

In the intervals between these ridges the wall of the auricle is very thin.

The blood enters the atrium of the auricle by the following openings:—(1) the opening of the superior vena cava; (2) the opening of the inferior vena cava; (3) the opening of the coronary sinus; (4) the orifices of one or two anterior cardiac veins from the surface of the right ventricle; (5) the foramina Thebesii.

The blood flows out of the cavity, into the right ventricle, through the large auriculo-ventricular opening.

The *orifice* of the *superior vena cava* is situated at the upper part of the auricle. The *inferior vena cava* opens into the lower part of the cavity. The dissector should note that these two veins are so directed that the currents of blood, which flow from them into the auricle, shall not be opposed the one against the other. The blood of the superior vena cava is directed towards the auriculo-ventricular opening, whilst the stream of blood flowing from the mouth of the inferior vena cava is directed so as to impinge against the septum between the auricles.

The *auriculo-ventricular* orifice is the large, oval opening situated in the lower part or floor of the auricle. Through this aperture three fingers can be readily passed into the ventricle. If the student now looks between this opening and the orifice of the inferior vena cava, he will discover the mouth of the *coronary sinus*, imperfectly guarded by a fold of endocardium, which receives the name of the *coronary valve* or *valve of Thebesius*. An attentive examination of the inner surface of the auricular wall will further reveal several minute, round, irregularly-scattered openings called the *foramina Thebesii*. Some of these are simply small cæcal pits in the substance of the heart, whilst others are the mouths of minute veins—the *venæ Thebesii*.

Examine, in the next place, the posterior wall of the right auricle. It is formed by the partition which separates the two auricles from each other. Upon this an oval depression, surrounded by a prominent ridge, will be

noticed a short distance above the mouth of the inferior vena cava. The depression is called the *fossa ovalis.* Its floor is exceedingly thin, and it marks the position of the *foramen ovale* of the fœtal heart. The ridge, which is deficient below, is crescentic in form, and is called the *annulus ovalis.* In a few cases, a communication between the two auricles may be found by slipping a probe under the upper and best-marked part of the *annulus.* Stretching between the anterior horn of the annulus ovalis and the anterior margin of the mouth of the inferior vena cava is a crescentic fold of endocardium, sometimes cribriform and often very feebly marked, called the *Eustachian valve.*

The dissector should now open with the scissors the superior vena cava and the two innominate veins. By this proceeding he may satisfy himself that *no valves* are present in these vessels.

Right Ventricle.—*Incisions.*—(1) A vertical incision through the anterior wall of the ventricle about a quarter of an inch to the right of the anterior interventricular furrow. Enter the knife above at the conus arteriosus, and carry it downwards, parallel to the furrow, to the right margin of the heart. (2) A transverse incision, through the anterior wall of the ventricle, from the upper end of the first incision to the right margin of the heart. This cut should be made parallel to the auriculo-ventricular groove, and about half an inch below it. Both incisions must be made with care and deliberation, but more especially the second one. In this case the auriculo-ventricular valve is liable to injury, and it is well to protect it by introducing the forefinger of the left hand through the auriculo-ventricular opening into the ventricle.

The anterior wall of the ventricle can, in this way, be raised in the form of a V-shaped flap and turned to the right. Wash away the blood and clots.

The cavity of the right ventricle, now laid open and

exposed to view, is of a somewhat triangular form, the base being directed upwards, and the apex downwards towards the apex of the heart. It does not reach this, however, but corresponds to the junction of the anterior and posterior interventricular furrows around the right sharp margin of the heart. On transverse section, the cavity

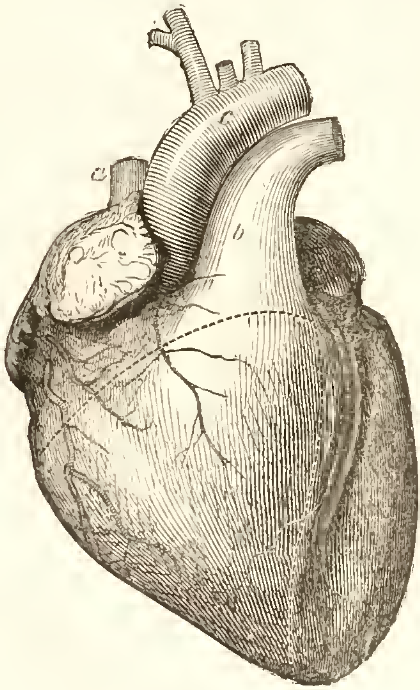

FIG. 44.

Diagram to show the manner in which the right ventricle should be opened. The dotted lines indicate the direction of the incisions. In the anterior interventricular furrow the coronary artery and the great cardiac vein are seen. *a*, Superior vena cava; *b*, Pulmonary artery; *c*, Aortic arch.

of the right ventricle is semilunar in outline. Owing to the thick fleshy interventricular septum which constitutes its inner and posterior wall bulging into it (Fig. 45). The wall is thickest at its upper part, and thins slightly towards the apex.

With the exception of the conus arteriosus, the interior of which is smooth and even, the inner surface of the

walls of the right ventricle is rendered extremely irregular by the projection of fleshy ridges called *columnæ carneæ.* It is customary to describe these as presenting three different forms—(*a*) simple elongated ridges; (*b*) fleshy slips free throughout the greater part of their extent, but fixed to the wall by their two extremities; (*c*) conical fleshy projections of considerable size, which project into the cavity, and are attached by their bases only. These last are called *musculi papillares,* and are arranged so as to form an anterior and a posterior set. The free end of

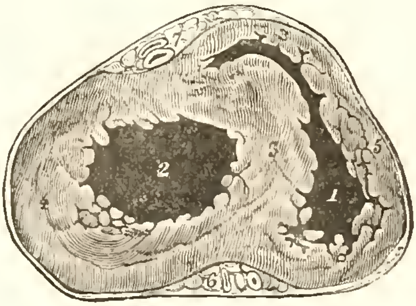

FIG. 45. (From Luschka.)

Transverse Section through the Ventricular part of the Heart.

1. Cavity of right ventricle.
2. Cavity of left ventricle.
3. Ventricular septum.
4. Thick wall of left ventricle.
5. Thinner wall of right ventricle.
6. Posterior interventricular furrow, with middle cardiac vein and posterior branch of right coronary artery.
7. Anterior interventricular furrow, with great cardiac vein and anterior branch of left coronary artery.

each of these papillary muscles gives origin to several delicate thread-like tendons—*the chordæ tendineæ*—and by these they are brought into connection with the segments of the auriculo-ventricular valve. A transverse fleshy band will be noticed to spring from the base of the anterior papillary muscle, and stretch across the ventricular cavity to the septum, to which it is attached. This is the *moderator band.* By fixing the yielding anterior wall of the

ventricle to the more solid septum, it is said to prevent over-distension of the cavity.

There are two openings in the right ventricle—(1) the *auriculo-ventricular*, which gives admission to the stream of blood; (2) *the pulmonary*, through which the blood passes into the pulmonary artery. Both these openings are situated at the base of the ventricle. The large oval auriculo-ventricular orifice lies to the right, close to the right margin of the heart, whilst the pulmonary aperture is placed to the left, in front of the other, and at the summit of the conus arteriosus. Both of these openings are guarded by valves, which act so as to give the blood its proper direction through the heart.

The *auriculo-ventricular valve*, also called *the tricuspid valve*, is composed of three triangular, pointed, membranous segments, termed *cusps*, which hang down into the cavity. They are united by their bases so as to form an annular membrane, and through the intermediation of this they are fixed around the auriculo-ventricular opening. In the intervals between these larger segments three smaller cusps may be detected.

Each cusp is composed of two layers of endocardium, between which there is a certain amount of fibrous tissue. This fibrous tissue is confined to the central portion of the cusp, the margins of which are therefore thin and translucent. When the valve is in action, it prevents regurgitation of blood into the auricle during the contraction of the ventricular wall. The thin marginal portions of the cusps are then in apposition, and afford to each other mutual support. The full brunt of the pressure has to be borne by the strong central part of each cusp. Attached to the ventricular surface and margins of each segment are several of the chordæ tendineæ which have been seen to take origin from the apices of the papillary muscles. In consequence of this, the ventricular surface of the valve is rough, whilst the auricular surface—that surface over which the blood flows—is smooth.

It is necessary, however, to note the relative position of these cusps. One, the largest of the three, is suspended so as to intervene between the auriculo-ventricular opening and the pulmonary orifice. It lies in front and to the left of the opening. This is the *infundibular cusp*. Another is placed posteriorly to the auriculo-ventricular

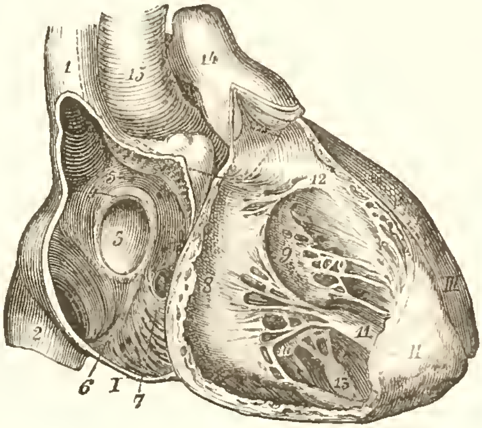

FIG. 46. (From Luschka.)

Interior of the Right Auricle and Right Ventricle.

1. Superior vena cava.
2. Inferior vena cava.
3. Fossa ovalis.
4. Annulus ovalis.
5. Foramina Thebesii.
6. Eustachian valve.
7. Opening of coronary sinus.
8. Infundibular cusp of tricuspid valve.
9. Septal cusp.
10. Marginal cusp.
11. Anterior papillary muscle.
12. Small papillary muscle on the septum.
13. Posterior papillary muscle.
14. Pulmonary artery.
15. Aorta.

I. Right auricle; II. Right ventricle; III. Left ventricle.

opening, and lies closely applied to the septum. This is the *septal cusp*. The third is situated to the right, near the margin of the heart, and may be termed the *marginal cusp*. The chordæ tendineæ of the anterior papillary muscle are distributed in the interval between the infundibular and marginal flaps: those from the posterior papillary muscle go to the interval between the marginal

and septal flaps; whilst to the interval between the infundibular and septal flaps pass a number of short chordæ tendineæ, some of which spring directly from the septum, whilst others proceed from low, feeble, musculi papillares, also connected with the upper part of the septum.

The valve which guards the mouth of the pulmonary artery is composed of three semilunar segments, and is called the *semilunar* or the *sigmoid valve.* By looking upwards into the lumen of the artery a view of these segments may be obtained, but it is better to defer their examination until the vessel itself has been studied.

Pulmonary Artery.—This vessel is a short wide trunk about two inches long. It has an oblique direction upwards and backwards, so as to reach the lower aspect of the transverse portion of the aortic arch. It here divides into a *right* and a *left* branch. At first it lies upon the root of the aorta, but, before it terminates, it is placed upon the left side of the ascending part of the aortic arch (Fig. 50, p. 240). In relation to each side of the pulmonary artery the dissector will notice the coronary artery and auricular appendix of that side. It is almost completely enclosed within the fibrous pericardium, the serous layer of which forms a single tubular sheath for it and the ascending aorta.

The *right pulmonary artery* is somewhat longer than the left. It passes transversely outwards behind the aorta and superior vena cava to reach the root of the right lung, where it has already been dissected (Fig. 50; 18). The *left pulmonary artery* runs outwards in front of the descending thoracic aorta and left bronchus to gain the root of the left lung (Fig. 50; 8). The blood is thus conducted from the right ventricle of the heart to the two lungs.

Obliterated Ductus Arteriosus.—A strong fibrous cord —the obliterated *ductus arteriosus*—will be observed connecting the root of the left pulmonary artery with the

under surface of the transverse portion of the aortic arch. The obliterated ductus arteriosus has the same direction as the trunk of the pulmonary artery. During fœtal life it is the patent continuation of the pulmonary artery, and conducts the blood into the aorta. At this period the

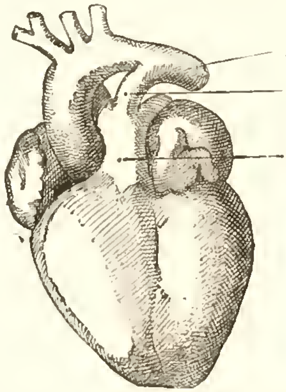

FIG. 47. (From Gegenbaur.)

Heart of a Seven Months' Fœtus.

right and left pulmonary arteries are of small size, and convey a very small part of the blood stream to the lungs. In dissecting the fibrous remains of the ductus arteriosus, note that the left recurrent laryngeal branch of the pneumogastric nerve hooks round it at its attachment to the aorta.

Pulmonary Valve.—The pulmonary artery may now be slit open, so as to expose the valve which guards its orifice. This incision must be made carefully, and the knife carried upwards through the wall in the interval between two of the three segments which enter into its formation. Each semilunar segment will be observed to be attached by its convex margin, whilst its concave border is free. Three minute pouches are thus formed around the mouth of the vessel, and the openings of these pouches are directed upwards. A good idea of the valve may be obtained by filling the pouches with cotton

wadding. The segments consist of a double layer of endocardium, strengthened by intermediate fibrous tissue, and if the free margin of one be taken between the finger and thumb, a minute nodule of cartilage may be felt about its middle. This is the *corpus Arantii*. In structure they are similar to the corresponding segments of the aortic valve —only weaker. We shall defer their more particular description, therefore, until the aortic valve is under consideration. Opposite each segment, the wall of the artery shows a slight dilatation or bulging, called the *sinus of Valsalva*. The three segments of the pulmonary valve are so placed, that two are in front and one behind the opening.

Pulmonary Veins.—The blood is conveyed back to the heart by the pulmonary veins. These have already been studied in the roots of the lungs. Two issue from each lung. The *right veins* are longer than the left, and pass inwards behind the superior vena cava and the right auricle. The *left veins* pass in front of the descending aorta. If the inferior vena cava be now divided and the heart turned upwards, the pulmonary veins will be seen opening into the left auricle upon its posterior aspect.

Left Auricle.—The only part of the left auricle which can be seen from the front is its appendix. This is narrower and more elongated than the corresponding portion of the right auricle. Its margin also is more distinctly notched. To open the left auricle, the heart must be turned well over to the right side of the body, and its apex tilted forwards. Fig. 48 shows the incision which should be made through its wall in order to display its interior. Enter the knife well back, and carry it obliquely forwards into the auricular appendix. The cavity is usually more or less distended with injection, and after this has been removed and the walls washed with warm water, the student will observe that the *musculi pectinati* are confined entirely to the appendix. Everywhere else the inner surface of the wall is smooth. On the posterior wall the

four openings of the *pulmonary veins* will be seen. In some cases the pulmonary veins of one or both sides unite before opening into the left auricle. The number of venous orifices is thus reduced. They are not provided with valves. In the lower and fore part of the auricle is the oval *auriculo-ventricular opening*. It only admits the

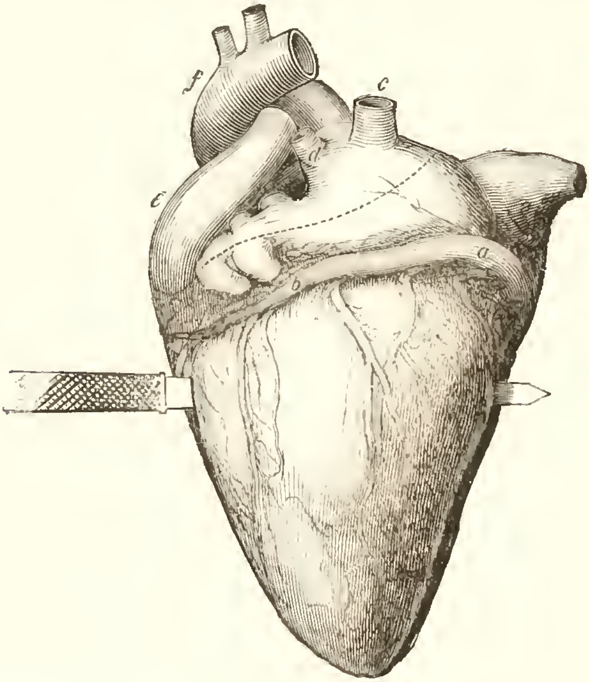

FIG. 48.

Diagram to show the manner in which the left auricle and left ventricle should be opened. The dotted line gives the direction in which the incision through the wall of tbe auricle should be made. *a*, Coronary sinus; *b*, Great cardiac vein; *c* and *d*, The two left pulmonary veins; *e*, Pulmonary artery; *f*, Aortic arch.

passage of two fingers into the ventricle, and is therefore smaller than the corresponding orifice of the right side. The position of the fœtal *foramen ovale* can also be distinguished upon this side of the septum between the auricles, but it is not so well marked as it is in the right auricle. It presents the appearance of a faint depression bounded below by a slightly marked crescentic border.

Left Ventricle.—To open the left ventricle, the dissector should stand upon the right side of the body and grasp the heart with the left hand, so that the forefinger rests upon the upper part of the posterior interventricular furrow, and the thumb upon the upper part of the anterior interventricular furrow. The wall of the ventricle should next be transfixed by a long knife (Fig. 48). Enter the knife below the thumb, about half an inch to the left of the anterior furrow, and push it through the ventricular wall towards the forefinger, so that the point emerges below this and half an inch to the left of the posterior furrow. Now carry the knife downwards towards the apex, but never allow it to come nearer to the furrows than it was when entered. If necessary, the cut on each side may be extended upwards towards the base of the ventricle with a small knife.

The cavity of the left ventricle is longer and narrower than that of the right ventricle. It reaches down to the apex of the heart, and is somewhat conical in shape —tapering towards its lower end. In cross section it presents a circular or broadly oval outline (Fig. 45, p. 226). The walls of the left ventricle are very much thicker than those of the right ventricle.

When the injection and blood have been washed away from the interior of the left ventricle with hot water, the *columnæ carneæ* will be observed to form dense reticulations on the inner surface of its walls. This network is especially complicated at the apex and on the posterior wall of the cavity. The surface of the septum and the upper part of the anterior wall is, comparatively speaking, smooth. The *musculi papillares*, with their attached chordæ tendineæ, are collected into two strongly marked groups. They are much larger than the papillary muscles of the right ventricle, and do not project so distinctly into the cavity.

The left ventricle has two openings—(1) the auriculo-ventricular opening, through which the blood enters from

the auricle; (2) the aortic orifice, through which the blood flows into the aorta. Both of these apertures are situated close together at the base of the ventricle, the *auriculo-ventricular* lying behind and to the left, whilst the *aortic orifice* is placed in front and to the right. Both openings are guarded by valves—the auriculo-ventricular opening by the *mitral* or *bicuspid valve*, and the aortic opening by the *aortic valve*.

The *mitral valve* prevents regurgitation of the blood into the left auricle during the contraction or systole of the ventricle. It consists of two large pointed cusps with two smaller portions intervening. These are similar in structure to the cusps of the tricuspid valve, but the segments are larger and much stronger and thicker. The fibrous tissue between the two layers of endocardium is more abundant, but it is arranged in precisely the same manner. The chordæ tendineæ from each musculus papillaris proceed to one of the two intervals between the cusps, and are attached to the adjacent margins and to the ventricular surfaces of the two cusps. Now look to the position which the cusps hold. The *anterior cusp* is the larger of the two, and lies in front and to the right of the opening, being so placed as to intervene between the two apertures at the base of the ventricle. Both surfaces of this segment are smooth, for the very obvious reason, that the stream of blood flows over both. The *posterior cusp* lies behind and to the left of the opening.

Looking upwards into the circular mouth of the aorta, the *aortic valve* will be seen. It is similar in all respects to the pulmonary valve, only its segments are stronger and thicker, and the sinuses of Valsalva at the root of the aorta are more strongly marked. The aortic valve will be studied more fully at a later stage of the dissection.

The above details will be dry and meaningless unless they are looked at in connection with the action of the heart during life. It is impossible to understand the construction of the heart unless we study at the same time its function. During life, the blood is driven through and from the heart by means of successive rhythmical contractions and

dilatations of its walls. But the entire heart does not act simultaneously. First, the auricles contract together, and this is succeeded by the contraction of the ventricles; in other words, the auricular contractions correspond to the ventricular dilatations, and *vice versâ*. But, again, there is a period immediately preceding the auricular contraction, during which the entire heart is at rest; and this is called the period of cardiac rest. These three conditions of the walls of the heart, viz.—(*a*) the cardiac rest, (*b*) the auricular contraction, (*c*) the ventricular contraction—follow each other consecutively and without intermission, the one after the other; and they are collectively termed "a cardiac revolution." Let us study what is going on inside the heart during each of these three stages.

During the *period of cardiac rest* the auricles are filling. Blood is flowing into the right auricle through the openings of the superior vena cava, inferior vena cava, and the coronary sinus; and into the left auricle through the orifices of the four pulmonary veins. A portion of this blood trickles down through the auriculo-ventricular openings into the ventricles; but the blood is passing into the auricles in greater quantity than it is trickling into the ventricles, and the result is, distension of the auricles. The second stage of the cardiac revolution now takes place—viz., *the auricular contraction*. The auricles contract sharply and suddenly, and the blood is forced through the auriculo-ventricular orifices into the ventricles. But how is it that the blood, during this contraction, does not regurgitate into the veins, the mouths of which are devoid of valves? For the simple reason that the contraction begins at the venous orifices, and travels towards the auriculo-ventricular openings; and partly because the column of blood which is already contained within the veins offers a barrier to the entrance of more. The ventricles are now full, and the third stage of the cardiac revolution takes place—viz., *the ventricular contraction*. The ventricles contract more slowly, and more deliberately than the auricles, and the blood is discharged into the pulmonary artery and into the aorta. Regurgitation of blood through the auriculo-ventriclar openings into the auricles is prevented by the tricuspid and bicuspid valves being thrown across these openings, and when the ventricular contraction ceases, regurgitation from the arteries into the ventricles is prevented by the semilunar valves being thrown across the arterial orifices.

As the blood is forced from the auricle into the ventricle, it passes from a narrow channel into a wider channel, and the result is that an eddy is produced in the ventricle, and the segments of the valve are floated up so as to close the orifice. In this position they are retained, and prevented from being forced upwards into the auricle during the ventricular contraction by the musculi papillares and the chordæ

tendineæ. As the ventricular wall in its contraction, to a certain extent advances towards the auriculo-ventricular opening, the musculi papillares, in their contraction, retreat from it, and keep the tendinous cords tense—never allowing them to slacken. When the contraction of the ventricle ceases, and the *vis a tergo* is removed from the blood, the recoil of the expanded wall of the artery exerts a pressure upon the column of blood. Its backward flow is prevented by the filling of the pouches of the semilunar valve.

The position of the different cardiac orifices, with reference to the anterior wall of the chest, is a matter of some importance. The *pulmonary* aperture is the most superficial, and lies behind the upper part of the junction of the third left costal cartilage with the left margin of the sternum. The *aortic opening* is placed more deeply and at a slightly lower level. It is situated behind the left margin of the sternum opposite the lower border of the junction, between the third left costal cartilage and the sternum. The *right auriculo-ventricular* orifice lies behind the sternum, close to the extremity of the fourth intercostal space of the right side. The *left auriculo-ventricular* opening is very deeply placed. It is situated behind the left margin of the sternum at the level of its junction with the fourth left costal cartilage.

The Arch of the Aorta.—The arch of the aorta should now be examined, and the various structures in relation to it must be carefully dissected out. The aorta is the great arterial trunk which conveys blood from the left ventricle of the heart, and distributes it by means of its branches to every part of the body. After leaving the heart it arches over the root of the left lung, and proceeds downwards in front of the vertebral column. It leaves the thoracic cavity by passing through a special opening in the diaphragm, and it ends in the abdominal cavity upon the left side of the body of the fourth lumbar vertebra, by dividing into the two common iliac arteries. The part of this great vessel which is contained within the chest is divided, for convenience in description, into two portions, viz. *the aortic arch* and the *descending thoracic aorta*. The level at which we make this arbitrary sub-division is the lower border of the body of the fifth dorsal vertebra.

The *aortic arch* takes origin from the base of the left ventricle of the heart, and proceeds obliquely upwards and

to the right behind the sternum. It also inclines, to some extent, forwards, so as to approach more closely to the anterior wall of the chest. Reaching the upper border of the *second costal cartilage* of the *right side* it changes its direction. In the first instance it bends upwards, and to the left in front of the trachea, and then turns suddenly backwards so as to gain the lower border of the body of *the fourth dorsal vertebra.* Here it makes a bend in a downward direction, and ends at the lower border of the body of the *fifth dorsal vertebra*, where it becomes continuous with the descending thoracic aorta. From the two decided changes in its direction it is customary to subdivide the aortic arch into an ascending, a transverse, and a descending portion. Each of these parts is contained in a different subdivision of the mediastinal space.

The *ascending portion* of the aortic arch extends from the base of the left ventricle, in a curved direction, to the upper border of the second right costal cartilage. For the most part it lies behind the sternum, but it projects slightly beyond the right margin of the bone at the level of the second intercostal space. Throughout almost its entire length it is enclosed within the fibrous pericardium, whilst the same sheath of serous pericardium surrounds it and the pulmonary artery. It is, therefore, placed within the middle mediastinum (Fig. 50; 15, p. 240).

It does not present a uniform diameter. At its root it presents, opposite the segments of the aortic valve, the three bulgings termed the sinuses of Valsalva; whilst higher up, on cross section, it generally presents a transversely oval and not a circular outline. This is due to the presence of a diffuse bulging of the right wall, which receives the name of the *great aortic sinus.* Against the wall of this sinus the blood is driven with great force as it leaves the ventricle, and at first sight it might seem to be aneurismal in its origin, but its presence in the fœtus renders such a view untenable. It is, however, a most favourite site for aneurismal dilatation.

The more immediate relations of the ascending part of the aortic arch may now be examined. It is intimately associated with the pulmonary artery throughout its entire length. At its origin it lies behind the pulmonary artery; higher up this vessel is placed to the left of the ascending aorta. To its right side is the superior vena cava, whilst behind, it is in relation to the left auricle and the right pulmonary artery (Fig. 50). The coronary arteries have already been seen to spring from this portion of the aorta.

The *transverse part** of the aortic arch extends from the upper border of the second right costal cartilage to the left side of the body of the fourth dorsal vertebra. It is placed within the superior mediastinum, and the left pleura is applied to its anterior or left aspect throughout almost its entire extent (Fig. 49). It lies behind the manubrium sterni, and is crossed, under cover of the left mediastinal pleura by the left superior intercostal vein, the left phrenic nerve, the inferior cardiac branch of the left pneumogastric nerve, the left superior cardiac branch of the sympathetic, and the left pneumogastric nerve, in that order from before backwards. At first the transverse part of the aortic arch lies in front of the trachea; afterwards it is placed to the left of the trachea, the œsophagus, thoracic duct, and the left recurrent laryngeal nerve (Fig. 49). The *upper border* of the transverse aorta is in relation to the left vena innominata, and from this aspect of the vessel three large arteries take origin, viz., from right to left—(*a*) the innominate, (*b*) the left common carotid, and (*c*) the left subclavian. Its *lower surface*, which forms the chief part of the concavity of the arch, overhangs the bifurcation of the pulmonary artery, and is connected with the root of the left pulmonary artery by the fibrous ductus arteriosus. Hooking round this surface is the recurrent laryngeal branch of the left vagus nerve.

* The term '*transverse*,' as applied to this portion of the aortic arch, is somewhat unfortunate, and is apt to convey an erroneous impression as to its direction (*vide* Fig. 49).

The *descending* portion of the aortic arch occupies the upper part of the posterior mediastinum. It lies upon the

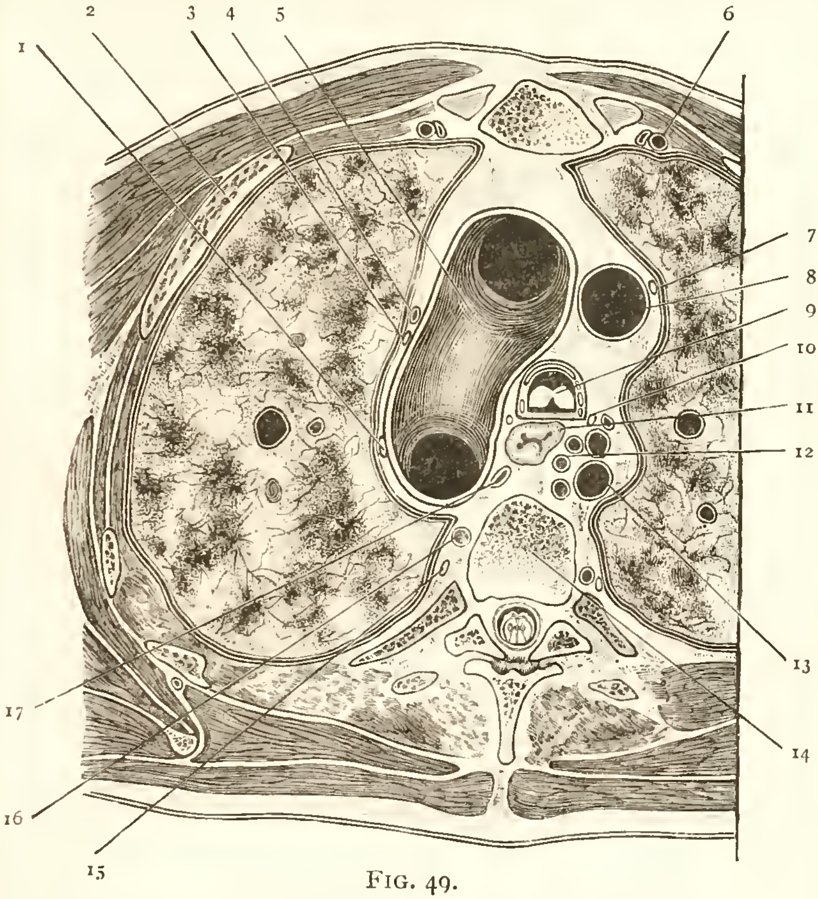

FIG. 49.

Transverse Section through the Thorax at the level of the fourth Dorsal Vertebra. This figure, and figure 7, p. 30, are taken from the same specimen, and fit together.

1. Left pneumogastric nerve.
2. Second rib.
3. Left phrenic nerve.
4. Left superior intercostal vein.
5. Transverse part of the aortic arch.
6. Internal mammary vessels.
7. Right phrenic nerve.
8. Superior vena cava.
9. Trachea.
10. Right pneumogastric.
11. Œsophagus.
12. Upper aortic intercostal arteries.
13. Vena azygos major.
14. Body of fourth dorsal vertebra.
15. Sympathetic cord.
16. Vena azygos minor superior.
17. Thoracic duct.

vertebral column to the left of the mesial plane, and

extends from the lower border of the body of the fourth dorsal vertebra to the lower border of the body of the

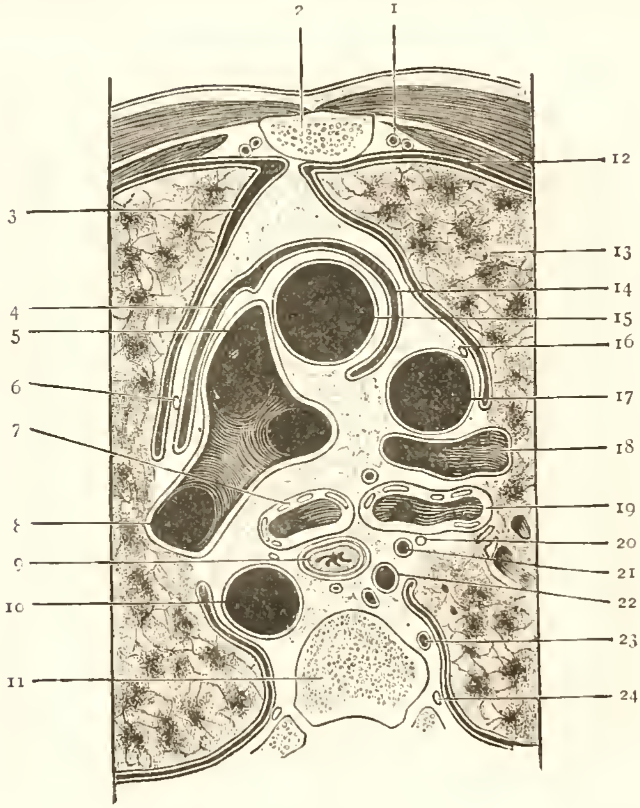

FIG. 50.

Section through the Mediastinal Space at the level of the fifth Dorsal Vertebra.

1. Internal mammary vessels.
2. Sternum.
3. Left pleural cavity.
4. Pericardium.
5. Pulmonary artery.
6. Left phrenic nerve.
7. Left bronchus.
8. Left pulmonary artery.
9. Œsophagus.
10. Descending part of aortic arch.
11. Fifth dorsal vertebra.
12. Right pleural cavity.
13. Right lung.
14. Pericardium.
15. Ascending aorta.
16. Right phrenic nerve.
17. Superior vena cava,
18. Right pulmonary artery.
19. Right bronchus.
20. Right pneumogastric nerve.
21. Bronchial artery.
22. Vena azygos major.
23. Intercostal artery.
24. Sympathetic cord.

fifth dorsal vertebra. It is clothed on the left side by the left mediastinal pleura. The œsophagus and thoracic

duct lie in relation to its right side, but on a plane somewhat anterior to it. Passing outwards in front of its lower part is the left pulmonary artery (Fig. 50; 10).

Branches from Aortic Arch.—The coronary arteries arising from the ascending aorta have already been studied. The three large branches which spring from the transverse part of the aortic arch carry blood for the supply of the two upper limbs and the head and neck. They should now be dissected. The left common carotid takes origin somewhat nearer the innominate artery than the left subclavian. They are all contained within the superior mediastinum, and Fig. 51, p. 242, which is taken from a tracing of a transverse section through the upper part of this space a short distance above the level of the aortic arch, shows their more important relations.

The Innominate Artery.—The innominate artery is the largest of the three branches. It passes obliquely upwards and to the right, and, gaining the posterior aspect of the right sterno-clavicular articulation, ends behind the upper margin of the clavicle, by dividing into the right common carotid and right subclavian arteries. *In front* of the vessel is the manubrium sterni, to the posterior aspect of which are attached the sterno-hyoid and sterno-thyroid muscles. Further, the artery is crossed superficially, and close to its origin, by the left vena innominata. *Behind* is the trachea; but as the vessel inclines to the right, it comes to lie, at a higher level, upon the right side of the windpipe. To the *right side* of the artery, in its upper part, are the pleura, the right innominate vein, and the right phrenic nerve.

With the exception of the two trunks into which it divides, the innominate artery is devoid of branches. The *thyroidea ima*, an occasional artery, may be seen to spring from it in some cases.

Left Common Carotid Artery.—This artery ascends to the posterior aspect of the left sterno-clavicular articu-

lation. At this point it leaves the thorax and enters the neck. It lies deeply in the thorax, at a greater distance from the manubrium sterni than the innominate artery.

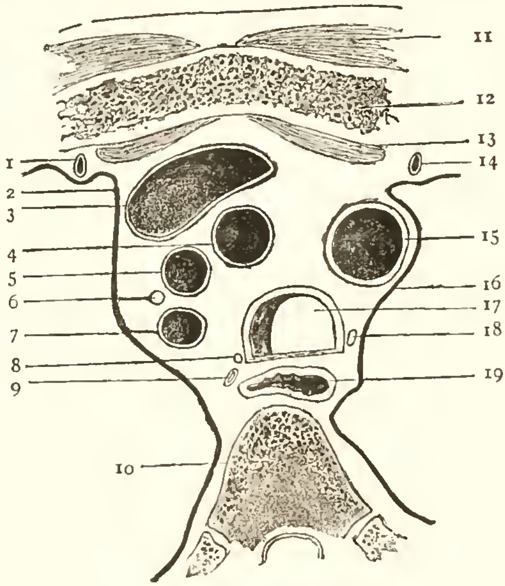

FIG. 51.

Tracing from a Section through the Superior Mediastinum at the level of the third Dorsal Vertebra.

1. Internal mammary artery.
2. Left mediastinal pleura.
3. Left innominate vein.
4. Innominate artery.
5. Left common carotid artery.
6. Left pneumogastric.
7. Left subclavian artery.
8. Left recurrent laryngeal nerve.
9. Thoracic duct.
10. Third dorsal vertebra.
11. Pectoralis major.
12. Sternum.
13. Sterno-hyoid and sterno-thyroid.
14. Internal mammary artery.
15. Right Innominate vein.
16. Right mediastinal pleura.
17. Trachea.
18. Right pneumogastric nerve.
19. Œsophagus.

In front of this vessel are the remains of the thymus gland, and the left vena innominata, which crosses it. *Behind*, it is in relation, in the first instance, to the trachea, and higher up to the œsophagus and thoracic duct. To its *left side* is the left vagus nerve. It gives off no branches within the thoracic cavity.

The Left Subclavian Artery, which springs from the transverse part of the aortic arch, near its termination, lies very deeply in the superior mediastinum. It takes a vertical course upwards towards the thoracic inlet, through which it passes by arching outwards over the cervical pleura and apex of the left lung to gain the upper surface of the first rib. *In front* is the left common carotid artery, and the left vena innominata and the left pneumogastric nerve. To *its right side* are the trachea and the left recurrent laryngeal nerve, and higher up, the œsophagus and thoracic duct. *Behind* and to *its left side* are the left mediastinal pleura and the left lung. In other words, the artery lies in a groove on the inner aspect of the apex of the left lung, and before the dissection of the mediastinum, if the apex of the lung be pulled outwards, the injected artery will be seen to bulge into the pleural cavity (Fig. 51).

Dissection.—The deep cardiac plexus should now be dissected. Divide the aortic arch at the commencement and termination of its transverse portion. Two ligatures should be placed around the vessel at each of these points and the section made between them. This is done to prevent the escape of the injection with which the artery is filled. The superior vena cava may also be severed immediately below the point where it is joined by the vena azygos major. By cutting the fibrous ductus arteriosus, the transverse portion of the aortic arch can be drawn aside so as to expose the trachea and the cardiac nerves in relation to it.

Cardiac Plexus.—There are three large nerve plexuses, formed in connection with the sympathetic system, in front of the vertebral column. One of these, the *cardiac plexus*, is situated within the thorax; the other two, the *solar* and the *hypogastric* with its pelvic prolongations, are placed within the abdomen.

The *cardiac plexus* is subdivided into a *superficial* and a *deep* portion, but these are in direct connection with each other, and are to be regarded merely as different parts of

one plexus. The *deep cardiac plexus*, on the other hand, is massed in two portions—a right and a left—which are united across the middle line by many communicating filaments.

The *superficial cardiac plexus* is small in comparison with the deep plexus. It has already been examined, and has been observed to lie in the concavity of the aortic arch in front of the bifurcation of the pulmonary artery. The *deep cardiac plexus* is situated behind the transverse portion of the aortic arch upon the lower end of the trachea. It is therefore placed on a deeper plane and at a higher level than the superficial plexus. The branches which enter the different parts of the cardiac plexus are derived from the cervical portions of the gangliated cords of the sympathetic, from the pneumogastric nerves, and from the recurrent laryngeal nerves.

The *sympathetic cardiac branches* are three in number on each side—one from each cervical ganglion—and they are termed, respectively, the *upper*, *middle*, and *lower sympathetic cardiac branches*. The *upper* sympathetic cardiac branch of the left side has already been traced across the front of the aortic arch into the superficial cardiac plexus. The *middle* and *lower* branches of the same side enter the thorax between the left subclavian and left common carotid arteries, and join the left portion of the deep cardiac plexus on the trachea. The *three* sympathetic cardiac branches of the *right side* join the right portion of the deep plexus. As they enter the thoracic inlet they pass behind the subclavian artery; in some cases, however, the upper and middle nerves may be noticed to pass in front of that vessel. Within the thorax they run obliquely downwards and inwards behind the innominate artery to reach their destination on the side of the trachea.

The cardiac branches of the pneumogastric nerves are given off partly in the neck and partly in the thorax. The *cervical branches*, with the exception of the lowest on each side, as a rule, join the sympathetic cardiac branches,

and thus lose their identity. The *lowest cervical cardiac branch* of the left pneumogastric has been previously traced in front of the aortic arch into the superficial cardiac plexus. The corresponding branch on the right side proceeds downwards in relation to the innominate artery, and joins the right portion of the deep cardiac plexus.

Thoracic cardiac branches are only given off from the trunk of the right pneumogastric. They join the right portion of the deep plexus.

The recurrent laryngeal branches of the pneumogastric nerves also supply cardiac twigs to the deep plexus. *On the left side,* where the recurrent laryngeal hooks round the arch of the aorta, these branches are more numerous, and replace the thoracic cardiac branches of the pneumogastric. The following table shows the arrangement of the cardiac nerves with reference to the plexus:—

Superficial cardiac plexus, .	1. Superior cardiac branch of sympathetic of left side. 2. Lowest cervical cardiac branch of left pneumogastric.
Left portion of the deep cardiac plexus, ...	1. Middle and lower cardiac branches of the sympathetic of left side. 2. Upper two cervical cardiac branches of the pneumogastric 3. Cardiac branches of the left recurrent laryngeal.
Right portion of the deep cardiac plexus, ...	1. Three cardiac branches of sympathetic of right side. 2. Cervical cardiac branches of the pneumogastric. 3. Thoracic cardiac branches of the pneumogastric. 4. Cardiac branches of the right recurrent laryngeal.

The manner in which the different offsets from the cardiac plexus are distributed has, to a certain extent,

been examined. From the right portion of the deep plexus proceed—(1) an offset to join the right anterior pulmonary plexus; (2) an offset for the supply of filaments to the right auricle of the heart; and (3) a very considerable prolongation, which passes downwards in front of the right pulmonary artery to join the superficial cardiac plexus, and form the *right coronary plexus* (p. 221).

From the left portion of the deep cardiac plexus proceed—(1) an offset to the left auricle; (2) an offset to the left anterior pulmonary plexus; whilst (3) the greater part of it is prolonged downwards in relation to the left pulmonary artery to form the *left coronary plexus* (p. 221).

Removal of the Heart from the Body.—To do this it is only necessary to divide the pulmonary artery and the pulmonary veins. The other vessels have already been severed. The ascending portion of the aortic arch which is attached to the heart should next be slit open, care being taken to carry the knife accurately between two of the segments of the valve so as not to injure either.

The Aortic Valve may now be studied and compared with the pulmonary valve which guards the mouth of the pulmonary artery. The membranous valve segments are three in number, and are of semilunar form. Attached around the opening by their convex margins, their free concave edges project into the lumen of the vessel. Three little pockets, open towards the interior of the artery, are in this manner produced. In the case of the *pulmonary artery* the segments are arranged so that two are in front and one to the back of the orifice. In the aorta, on the other hand, one lies to the front and two to the back of the opening, and on looking into the sinuses of Valsalva, which correspond to the segments, the orifices of the coronary arteries will be seen. Note that they are placed, as a rule, opposite the free edges of the corresponding valve segments, and further, that the right

artery springs from the anterior sinus of Valsalva, and the left artery from the left posterior sinus of Valsalva. There are no such openings to be seen in the pulmonary artery.

The aortic valve segments are constructed upon a stronger plan than the pulmonary segments, although in both the structure is the same. In the aortic segments the fibrous tissue which intervenes between the two layers of endocardium is more abundant, and the corpora Arantii more apparent. The fibrous tissue is not uniformly distributed throughout the valve segment, as may be seen by placing one of them on the point of the finger. A firm cord runs along the free edge, and also along the attached border. In addition to this, the fibrous tissue is spread out in the segment in a uniform layer, except in two localities called the *lunulæ.* These are semilunar in outline and lie next the free margin—one on either side of the corpus Arantii. These *lunulæ* are thin and transparent, seeing that they are formed of little more than the two opposed layers of endocardium. When the valve is in action and opposing the return of blood into the heart during diastole of the ventricles, the thin lunular portions of the valve segments are closely applied, and afford mutual support to each other. The full brunt of the blood pressure is borne by the stronger portions of the valve segments.

Cardiac Wall.—The last step in the dissection of the heart consists in the examination of the parts which enter into the formation of the cardiac wall. On the outside, the heart is clothed by *epicardium* or serous pericardium, and on the inside its cavities are lined by the thin smooth *endocardium* which is continuous through the orifices with the lining membrane of the veins and arteries, and takes a large share in the construction of the valve-flaps. Between the epicardium and the endocardium is placed the muscular tissue of the heart, which is termed the *myocardium.* The muscular fibres of the heart are disposed in

*

several layers, in each of which the fibres take a special direction.

But in an ordinary dissecting-room heart very little information can be obtained as to the arrangement of the muscular fibres. The continuity of the walls is destroyed by the openings which have been made to obtain a view of the interior of the different chambers. It is better, therefore, to obtain a fresh sheep's heart. After filling it with a thick mixture of flour and water, it should be boiled for a quarter of an hour. The boiling has the effect of expanding the paste, while at the same time it dissolves the connective tissue, and hardens the muscular fasciculi. When the boiling is completed, the heart should be placed in cold water, and the dissection carried out. The epicardium and the muscular fibres should be torn off, and not cut with the scalpel.

The fibres of the auricles are difficult to dissect; but in the ventricular portion of the heart, the student should be able to make out—(1) that the different layers of muscular fasciculi cross each other obliquely, and are for the most part attached to the fibrous rings which encircle the auriculo-ventricular openings; (2) that the superficial fasciculi are common to both ventricles; (3) that the majority of the fasciculi of the left ventricle bend inwards at the ventricular septum; and (4) that a remarkable spiral or whorled arrangement of fibres (whorl or vortex) occurs at the apex of the heart.

The heart which is obtained in the dissecting-room, however, must not be cast aside, because several very essential and important points may be made out by its further dissection. In the first place, it is easy to determine the relation of the auricles and ventricles. By separating the epicardium from the base of the ventricles and the adjacent part of the auricles, and removing the fat and vessels from the auriculo-ventricular furrow, it will be seen that the muscular tissue which enters into the formation of the ventricular walls is quite distinct from that of the auricular walls. The bond of union between the auricles and ventricles consists of two fibrous rings which surround the auriculo-ventricular openings. By removing the auricles with a pair of scissors these can be more fully displayed. It is to these rings that the triangular auriculo-ventricular valve-cusps are attached, and it is from them that they derive the fibrous tissue

which intervenes between the two layers of endocardium which form them. Two fibrous rings are also placed around the arterial openings, and supply the strengthening fibrous tissue to the semilunar valve segments.

When the auricles are removed from the ventricles, the relative positions of the orifices at the base of the ventricular portion of the heart can be studied. The auriculo-ventricular openings lie posteriorly and side by side. The aortic opening is placed in front and between them, whilst the pulmonary orifice is situated in front of the aortic opening. A wide interval intervenes between the apertures of the right ventricle: the aortic and left auriculo-ventricular orifices, however, lie close together, and their fibrous rings for a short distance are confluent with each other. In the triangular interval, between the aortic and left auriculo-ventricular opening, a small piece of fibro-cartilage which stands in connection with the fibrous rings may be discovered.

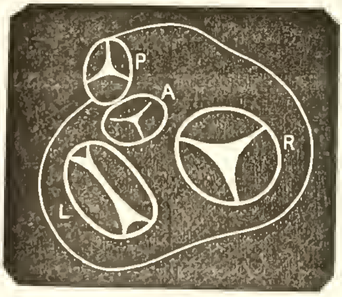

FIG. 52.

Diagram of the Base of the Ventricular portion of the Heart.
P. Pulmonary opening.
A. Aortic opening.
L. Left auriculo-ventricular opening.
R. Right auriculo-ventricular opening.

Trachea and Bronchi.—The thoracic portion of the trachea, or wind-pipe, traverses the superior mediastinum. To expose it more fully, separate the two pulmonary arteries with the knife, and throw each outwards towards the lung with which it is connected. The transverse portion of the aortic arch must be drawn aside, and some bronchial glands which occupy the angle between the bronchi removed.

The *trachea* is a wide tube, which is kept constantly patent by a series of cartilaginous rings which are embedded in its walls. Posteriorly these rings are deficient, and in consequence the tube is flattened behind. Its appearance

in transverse section may be seen in Fig. 49, p. 239. It begins in the neck opposite the sixth cervical vertebra, where it is continuous with the larynx, and it enters the chest cavity through the thoracic inlet. Here it lies in the superior mediastinal space, and ends by dividing into the two bronchi opposite the intervertebral disc between the 4th and 5th dorsal vertebræ. Except at its lower end, which is very slightly inclined to the right, it adheres rigorously to the mesial plane.

The relations of the thoracic part of the trachea are as follows:—*In front*—(1) the manubrium sterni, to the posterior aspect of which the sterno-hyoid and sterno-thyroid muscles are attached; (2) the remains of the thymus body; (3) the left innominate vein; (4) the transverse portion of the aortic arch and the origins of the innominate and left common carotid arteries; (5) the deep cardiac plexus. *Behind*, it rests upon the œsophagus, which lies somewhat to the left side of the mesial plane. On its *right side* are the pleura and the right pneumogastric nerve, and at a higher level the innominate artery; and on its *left side* are the left recurrent laryngeal nerve, and the left subclavian artery.

The two bronchi differ considerably from each other. The *right bronchus* is shorter and wider than the left, and appears to be more directly in a line with the trachea. The vena azygos major passes forwards in contact with its upper surface. The superior vena cava and the right pulmonary artery lie in front of it (Fig. 50). The *left bronchus* is longer and narrower than the right. As it passes outwards and downwards it crosses in front of the œsophagus and the descending aorta, and behind the left pulmonary artery (Fig. 50). From its postero-inferior aspect a slender muscular slip may, in some cases, be observed to take origin. This fasciculus connects it with the œsophagus, and is therfore called the *broncho-œsophageal* muscle.

The relations of the bronchi in the roots of the lungs have already been studied (*vide* p. 203).

Posterior Mediastinum.—This is the term which is applied to that part of the interpleural space which lies behind the pericardium. It may be regarded as a continuation downwards of the posterior part of the superior

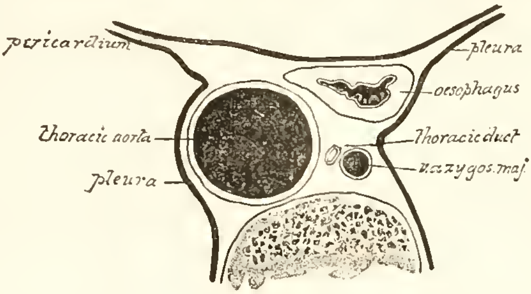

FIG. 53.

Tracing from a Transverse Section through the Posterior Mediastinum at the level of the sixth Dorsal Vertebra. At this level the section passes through the root of the Lung. The Pleura and Pericardium are therefore represented in a somewhat diagrammatic manner.

mediastinum, and many of the structures in the one are prolonged downwards into the other. The arbitrary upper limit of the posterior mediastinum is the lower border of the fourth dorsal vertebra. *In front*, it is bounded by the

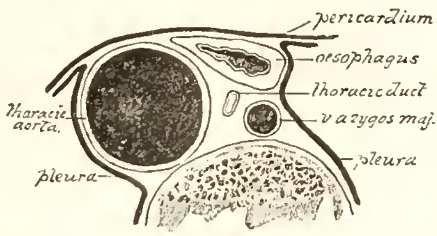

FIG. 54.

Tracing of a Transverse Section through the Posterior Mediastinum at the level of the seventh Dorsal Vertebra. The Pulmonary Veins are divided at this level as they pass inwards through the fibrous Pericardium, but they are not represented; and therefore the Pericardium and Pleura are represented in a diagrammatic manner.

pericardium, except in its very lowest portion, where the anterior wall is formed by the posterior surface of the diaphragm (Fig. 56). *Behind*, it is limited by the bodies of the dorsal vertebræ below the fourth, and *on each side*

by the mediastinal pleura as it passes back from the pericardium to the spine. In transverse section its outline is quadrilateral. Figures 53 to 56 are taken from tracings of a series of transverse sections through the space. They serve to show the character of the space and the relative positions of some of the more important contents. The following is a list of the structures which it contains:—

1. The thoracic aorta.
2. The œsophagus.
3. The pneumogastric nerves.
4. The thoracic duct.
5. The vena azygos major.
6. The vena azygos minor superior.
7. The vena azygos minor inferior.
8. The great splanchnic nerves.
9. Some lymphatic glands.

To open into the space it is necessary to make a vertical incision through the pericardium, which forms its anterior wall. Carry the knife along the line of the œsophagus,

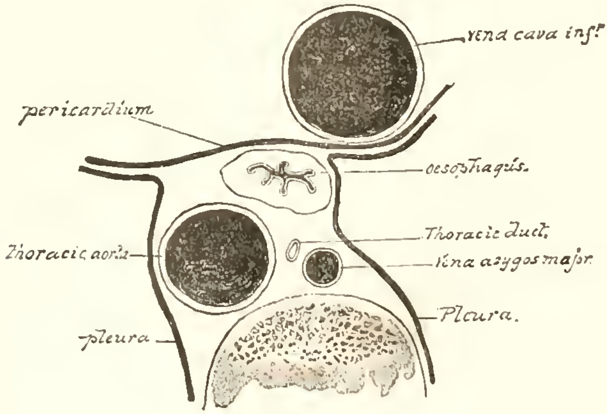

FIG. 55.

Tracing of Section through the Posterior Mediastinum at the level of the eighth Dorsal Vertebra.

and throw the pericardium outwards. If this be done with care, a fleshy band may, in some cases, be observed crossing the superficial aspect of the thoracic aorta, and extending from the œsophagus to the pleura, which forms the left lateral wall of the posterior mediastinal space. This is the *pleuro-œsophageal muscle*. In the majority of cases,

however, this muscle is only represented by a few slender musculi fasciculi which are difficult to isolate from the areolar tissue in which they lie.

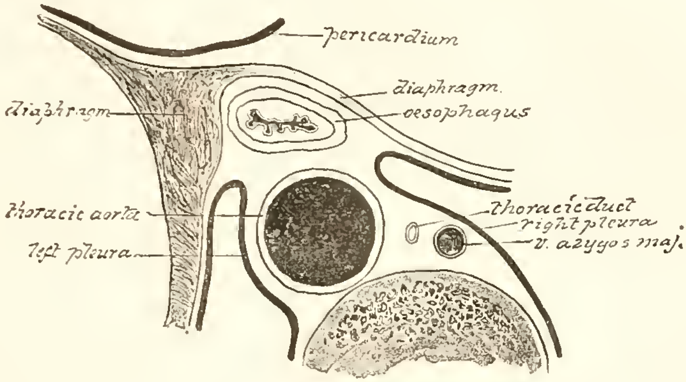

FIG. 56.

Tracing of a Section through the lower part of the Posterior Mediastinum, where its Anterior Wall is formed by the Diaphragm.

Pneumogastric Nerves.—The pneumogastric nerves can now be followed throughout their entire course within the thorax. They traverse both the superior and posterior mediastinal spaces, but differ so much in their relations on the two sides of the body that it is best to examine each separately.

The *left pneumogastric* nerve enters the thorax in the interval between the left common carotid and left subclavian arteries, and behind the left innominate vein (Fig. 51). It has already been observed crossing the arch of the aorta behind and to the left side of the phrenic nerve and the two superficial cardiac nerves (Fig. 49). Here also it has been seen to give off its recurrent laryngeal branch. Leaving the aorta, it sinks behind the root of the left lung (Fig. 50), and at once breaks up into a number of branches, which unite in a plexiform manner to form the *left posterior pulmonary plexus*. It issues from this plexus in the form of one or two cords, which pass to the anterior aspect of the œsophagus. Upon the œsophagus another plexus—the

plexus gulæ—is formed; but this plexus differs from the pulmonic plexus, inasmuch as the pneumogastric nerves of both sides take part in its formation. From the plexus gulæ, the left pneumogastric emerges as one trunk, and passes out of the thorax by the œsophageal opening of the diaphragm. It is distributed within the abdomen upon the anterior surface of the stomach.

The *right pneumogastric nerve*, in the upper part of the superior mediastinum, lies deeper in the thorax than the left nerve. It enters by passing between the subclavian artery and the right innominate vein, and descends by the side of the trachea to the posterior aspect of the root of the right lung. Here it breaks up into the *right posterior pulmonary plexus*, and, issuing from this in the form of two nervous cords, it takes part in the formation of the *plexus gulæ*. It leaves this plexus upon the posterior aspect of the œsophagus, and, entering the abdomen through the œsophageal opening of the diaphragm, it is distributed to the stomach upon its posterior surface.

The pneumogastric nerves give off the following branches within the thorax:—

1. Recurrent laryngeal.
2. Thoracic cardiac.
3. Pulmonary.
4. Œsophageal.

The *left recurrent laryngeal* nerve springs from the pneumogastric as it crosses the arch of the aorta. It hooks round the transverse part of the aortic arch, or rather the attachment of the fibrous ductus arteriosus to the under surface of the arch, and reaching the trachea, ascends by the side of this to the larynx. The *right recurrent laryngeal* nerve arises in the root of the neck, and hooks round the subclavian artery.

The *thoracic cardiac* branches of the right side proceed in part from the pneumogastric and in part from the recurrent laryngeal nerve of that side. On the left side of

the body they are derived from the left recurrent laryngeal nerve as it turns round the aortic arch.

The *pulmonary branches* have already been studied in connection with the root of the lung (*vide* p. 202).

The *œsophageal branches* are dispensed to the gullet in two sets—(1) a few delicate twigs are given by the pneumogastric before it enters the pulmonary plexus to that portion of the œsophagus which lies in the superior mediastinum; (2) numerous filaments are supplied by the plexus gulæ to that part of the œsophagus which is placed in the posterior mediastinum.

Œsophagus.—The thoracic portion of the œsophagus should next be studied. It lies partly in the superior mediastinum and partly in the posterior mediastinum. It is the narrowest, but at the same time the most muscular, part of the alimentary canal. It descends in front of the spine, following its antero-posterior curvature, and leaves the thoracic cavity opposite the tenth dorsal vertebra by passing through the œsophageal opening of the diaphragm. The œsophagus does not pursue a straight course through the thorax: it enters somewhat to the left of the middle line; but on tracing it downwards, it will be noticed to incline inwards, so as to assume a mesial position opposite the fifth dorsal vertebra. From this it again deviates to the left so as to gain the œsophageal opening in the diaphragm.

In the superior mediastinum the œsophagus lies immediately behind the trachea (Fig. 49); below this it is crossed by the left bronchus, with which it is sometimes connected by the broncho-œsophageal muscle (Fig. 50). From this point onwards through the posterior mediastinum it is covered in front by the pericardium, which is applied closely to it (Figures 53 to 55). Just before entering the abdomen it lies behind the posterior part of the diaphragm (Fig. 56). From above downwards, therefore, the immediate anterior relations of the œsophagus are: (1) trachea; (2) left

bronchus; (3) pericardium; (4) diaphragm. *Behind*, the gullet lies, except at its lower end, in front of the vertebral column, but there are many structures which intervene between them. Thus, in the superior mediastinum the longus colli muscle separates the gullet from the spine, while in the posterior mediastinum it is placed in front of the vena azygos major and the thoracic duct, and the vena azygos minor inferior and the right intercostal arteries cross behind it. In its lower part, the gullet inclines forwards and to the left, so that it comes to rest directly upon the anterior surface of the thoracic aorta. These relations are seen in Figs. 53 to 56. Upon *the right side*, during its course through the posterior mediastinum, the œsophagus is clothed by the mediastinal pleura, whilst on the *left side* it is related in the posterior mediastinum to the thoracic aorta, except where in its lower part it lies in front of that vessel. In the superior mediastinum the thoracic duct is closely applied to the left side of the œsophagus, and the left pleura comes into partial relationship with it. Below, this, however, it is not directly related to the pleura of the left side. Lastly, bear in mind that the pneumogastric nerves form the plexus gulæ on the walls of the gullet, as it traverses the posterior mediastinum. Finally they accompany it in the form of two nerve-trunks through the œsophageal opening—the right nerve being placed on its posterior aspect, whilst the left nerve is placed in front of it.

The Descending Thoracic Aorta.—The thoracic aorta is the direct continuation of the aortic arch, and it traverses the posterior mediastinum. It begins at the lower border of the fifth dorsal vertebra, and ends opposite the last dorsal vertebra by entering the abdomen through the aortic opening of the diaphragm, and becoming the abdominal aorta. At its commencement it lies somewhat to the left of the middle line, but as it proceeds downwards it inclines inwards, so that at its termination it is mesial

in position. It lies upon the bodies of the vertebræ, and therefore it shows a curve corresponding to that of the vertebral column in the dorsal region. *In front*, it is covered by the pericardium, and is crossed by the root of the left lung. *Behind*, it rests upon the vertebral bodies and the intervening intervertebral discs, whilst crossing behind it, the dissector will observe the vena azygos minor inferior, and, in many cases, the vena azygos minor superior. To *the left side*, and closely applied to the vessel, is that part of the pleura which forms the left lateral wall of the posterior mediastinum; whilst on *its right side* will be noticed the thoracic duct and the vena azygos major.

The œsophagus has a varying and important relationship to the thoracic aorta. At first it lies to the *right* of the aorta, but as it approaches the diaphragm it inclines to the left and comes to lie *in front* of the vessel; and lastly, before it passes through the œsophageal opening of the diaphragm it is somewhat to its *left side*.

The branches of the thoracic aorta may be grouped under the heads of *visceral* and *parietal*.

Visceral.	Bronchial. Pericardiac. Œsophageal. Posterior Mediastinal.
Parietal.	Intercostal (nine on each side).

The *bronchial arteries* are usually three in number—*two* for the left lung and *one* for the right lung. They are very variable in their manner of origin. The *right* bronchial artery often springs from the first aortic intercostal artery. The *left* bronchial arteries generally take origin from the aorta. They run upon the posterior aspect of the corresponding bronchus, and they have already been studied as constituent parts of the roots of the lungs. In the substance of the lung they follow the bronchi, and show a similar branching and distribution.

The *bronchial veins* are of small size. The *left* opens

into the vena azygos minor superior; the *right* joins the vena azygos major.

The *pericardiac* branches are some minute twigs which are distributed to the posterior aspect of the pericardium. The *œsophageal* arteries are the vessels of supply to the gullet. They are four or five in number, and are irregularly placed. They spring from the front or right side of the aorta, and form a chain of anastomosis on the wall of the œsophagus. Above, this chain communicates with branches of the inferior thyroid artery, whilst below, it communicates with the ascending branches of the coronary artery of the stomach. The *posterior mediastinal* branches are very small, and are given to the areolar tissue and glands in the posterior mediastinal space.

The *intercostal branches* will be observed arising in pairs from the posterior aspect of the aorta. Defer their examination, however, until the thoracic duct and the sympathetic cords have been dissected.

The Thoracic Duct.—The thoracic duct, although a vessel of small calibre, is of high importance. It receives all the lymphatic vessels of the body below the diaphragm (except from part of the upper surface of the liver), the lymphatics of the left side of the chest (including the left lung and left side of the heart), and the lymphatics of the left superior extremity and left side of the head and neck. It will be found by dissecting in the loose areolar tissue which lies between the aorta and the vena azygos major. Its diameter is not much greater than whip-cord, and it will be recognised from its position and by the great elasticity which it exhibits when it is pulled by the forceps. Trace it downwards, and it will be found to enter the thorax upon the right side of the aorta, and through the same opening in the diaphragm. It commences within the abdomen upon the second lumbar vertebra in a dilatation called the *receptaculum chyli*. Follow it upwards, and it will be noticed to incline gradually to the left. At the

level of the fourth dorsal vertebra it passes behind the aortic arch and œsophagus. It now ascends to the neck between the œsophagus and left pleura, and ends by joining the internal jugular vein at its point of union with the subclavian vein. In the series of diagrams which are given of the posterior and superior mediastinal spaces, the relations of the thoracic duct may be studied (Figs. 49 to 56). It will be seen that in the posterior mediastinum it lies behind the œsophagus, but in the superior mediastinum it is placed upon the left side of the œsophagus. In the former situation, before the parts are disturbed by dissection, it can readily be exposed by raising the *right lung* and dividing the right mediastinal pleura: in the latter situation, the *left lung* must be raised and the left mediastinal pleura divided. As it passes upwards through the thorax, the thoracic duct pursues a somewhat wavy or flexuous course. It frequently breaks up into two or more branches, which unite again to form a single trunk. It is provided at intervals with valves of two segments, and these, when the duct is injected, give it a beaded or nodulated appearance. The valves are more especially numerous in the upper part of the duct.

Thoracic Lymphatic Glands.—Throughout the dissection of the thorax the dissector has, from time to time, met with groups of lymphatic glands. It would be well to bring these more distinctly under notice, seeing that their enlargement in disease is not unfrequently the cause of serious thoracic trouble. The following are the chief groups: (1) Two chains of minute glands, which are placed in relation to the anterior thoracic wall, and follow the course of the internal mammary vessels. They are termed *sternal glands*, and are joined by lymphatic vessels from the anterior thoracic wall, the mammary glands, the front part of the diaphragm, and the upper part of the front wall of the abdomen. (2) Two chains of glands on the posterior thoracic wall—one on either side of the spine in relation to the vertebral extremities of the ribs. They are very minute, and offsets from these chains accompany the intercostal vessels between the intercostal muscles. They are therefore called the *intercostal glands*, and they receive the lymphatics of the posterior thoracic wall. (3) *Anterior mediastinal glands*, two or three in number, and receiving lymphatics from the

diaphragm and upper surface of the liver. They occupy the lower open part of the anterior mediastinum. (4) *Posterior mediastinal glands*, following the course of the thoracic aorta, and joined by lymphatics from the diaphragm, pericardium, and œsophagus. (5) *Superior mediastinal glands*, an important group, eight to ten in number, and placed in relation to the aortic arch. The lymphatics of the heart, pericardium, and thymus body enter them. (6) *Bronchial glands*, continuous above with the preceding, and massed chiefly in the interval between the two bronchi. They are also prolonged into the roots of the lungs. The lymphatic vessels of the lungs pour their contents into them. In the adult they are generally dark in colour, and sometimes as black as ink.

The lymphatics of the right side of the chest, the right lung, and the right half of the heart, join *the right lymphatic duct*, a minute and short vessel situated in the root of the neck. It opens into the angle of union between the right internal jugular and right subclavian veins.

Removal of the Lungs.—The lungs may now be removed by dividing the trachea about an inch and a-half above its bifurcation. The bronchi and vessels should be traced into the lobes of the lungs, and their manner of subdivision and distribution throughout its substance studied.

The student has previously observed that the two lungs are not symmetrical. The right lung is subdivided into three lobes, whilst the left lung is cleft into two lobes. The bronchi exhibit a corresponding want of symmetry. Each tube, as it approaches the pulmonary hilum, divides into branches for the different lobes. The *right bronchus* gives off two such branches for the upper and middle lobes of the right lung respectively, whilst the main stem of the tube sinks into the inferior lobe. The *left bronchus* sends off a large branch to the upper lobe of the left lung, and then enters the lower lobe. The first branch of the right bronchus leaves the main stem about one inch from the trachea. The first branch of the left bronchus, on the other hand, takes origin about twice that distance from the trachea.

But the relation of the pulmonary artery to the bronchial subdivisions is different on the two sides. In both cases it lies in front of the undivided portion of the tube, but

on the right side it turns backwards, so as to reach the posterior aspect of the bronchus below the first and above the second division. It is due to this arrangement that the right bronchus occupies the highest level in the right pulmonary root. On the left side, the pulmonary artery turns

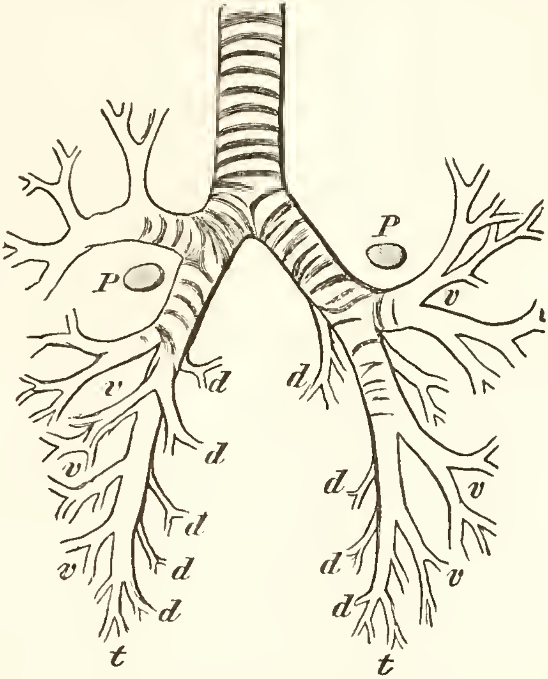

FIG. 57. (From Gegenbaur.)

Schema of the branching of the two Bronchi.

P. Pulmonary artery.
d. Dorsal divisions of the bronchi.
v. Ventral divisions of the bronchi.

The highest *v* on each side indicates the first hyparterial bronchus, or, in other words, the branch to the upper lobe of the left side and the middle lobe on the right side.

backwards above the level of the first bronchial branch, and therefore holds the highest place in the left pulmonary root. On the right side, then, the first bronchial branch is placed above the pulmonary artery, and it is termed the *eparterial bronchus;* all the others lie below it,

and are termed *hyparterial bronchi.* On the left side there is *no eparterial* tube; they are all *hyparterial.* A consideration of these relations led Aeby to conclude that the eparterial bronchus, and the upper lobe of the right lung to which it goes, are not represented on the left side of the body. In other words, he believed that the middle lobe of the right lung is the representative of the upper lobe of the left lung.

When the main stem of the bronchus is followed into the inferior lobe on either side, it will be observed to travel downwards towards the back part of the base, and give off, as it proceeds, a series of large *ventral,* and a series of smaller *dorsal* branches. The first hyparterial division on each side (*i. e.* the branch to the middle lobe of the right side, and the branch to the upper lobe of the left side) may be regarded as the first member of the ventral group (Fig. 57).

The *pulmonary vessels* in the substance of the lungs run with the bronchi. The *veins* still keep to the front of the air passages; the *arteries,* however, as we have noted, turn backwards to reach their posterior aspect, and this relation they maintain in the lung-substance.

It should be observed that when the bronchial tubes enter the lung, they cease to be flattened posteriorly, and become uniformly cylindrical. This is due to the cartilage being disposed around the tube on all its aspects, in the form of irregular flakes, and imperfect rings. The further the tubes are traced, the scarcer and finer become the particles of cartilage.

Gangliated Cord of the Sympathetic.—The dissector should next turn his attention to the thoracic portion of the sympathetic nervous system. In order to expose it, he must strip the parietal pleura from the sides of the vertebræ and the inner surface of the ribs. He will then observe the gangliated cord extending through the thoracic cavity. It lies upon the heads of the ribs and the intervening inter-

costal spaces, and has an appearance somewhat similar to a knotted string. It requires considerable care to make a good dissection of the various ganglia and their branches. The thoracic ganglia are usually twelve in number, and, with the exception of the two lowest, they are placed upon the heads of the upper ten ribs. Towards the diaphragm the cord inclines forwards, so that the two lowest ganglia come to lie upon the bodies of the two last dorsal vertebræ. The first ganglion is considerably larger than those which succeed it. They are all linked together by intervening nervous cords. Superiorly, the thoracic part of the sympathetic is continuous with the cervical sympathetic; whilst inferiorly it becomes continuous with the abdominal portion of the sympathetic by passing behind the ligamentum arcuatum internum of the diaphragm.

The branches which spring from the ganglia may be divided into an *external* and an *internal* series.

The *external* series are branches of communication between the ganglia and the intercostal nerves. Two run between each nerve and the corresponding ganglion. These differ in the kind of fibres which compose them. One is chiefly composed of white cerebro-spinal nerve-fibres; the other is mainly formed of grey sympathetic nerve-fibres. Through the agency of these two twigs, an interchange of fibres takes place between the intercostal nerve and the sympathetic ganglion.

The *internal* series are branches of distribution. From the *upper five* or *six* ganglia the internal branches go to thoracic viscera, whilst in the case of the *lower six* ganglia, the internal branches unite to form the splanchnic nerves which are destined for the supply of abdominal viscera. The *thoracic twigs* of supply are very small, and are given to the aorta, to the vertebræ and their ligaments, and to the lungs. The pulmonary branches proceed from the third and fourth ganglia, and they enter the posterior pulmonary plexus. *The splanchnic nerves* are three in

number, and are distinguished by the terms *great*, *small*, and *smallest*.

The *great splanchnic nerve* is formed by the union of five roots derived from the sixth, seventh, eighth, ninth, and tenth ganglia. This description, however, must be regarded as being somewhat arbitrary, as there is great variability in the number and manner of origin of the roots of this nerve. It is said that, under certain circumstances, filaments may be followed upwards upon the sympathetic cord as high as the third or even the first ganglion. The great splanchnic has more the appearance of a cerebro-spinal nerve than a sympathetic nerve, owing to the large amount of spinal nerve-fibres which it contains. It passes downwards upon the bodies of the vertebræ, and leaves the thorax by piercing the crus of the diaphragm. Within the abdomen it ends by joining the semilunar ganglion.

Upon the last dorsal vertebra, a ganglion called the *great splanchnic ganglion* will in all probability be found in connection with the great splanchnic nerve. This ganglion is usually of small size, involving only a very few of the anterior fibres of the nerve. Sometimes, however, it forms a distinct oval bulging on the nerve-trunk. A few slender filaments are given by the ganglion to the coats of the aorta, and these in some cases may be made out to communicate across the middle line of the body with the corresponding branches of the ganglion of the opposite side.

The *small splanchnic nerve* arises by two roots from the tenth and eleventh thoracic ganglia. It enters the abdomen by piercing the crus of the diaphragm, and it ends by joining the cœliac part of the solar plexus.

The *smallest splanchnic nerve* is a minute twig which takes origin from the twelfth thoracic ganglion. It pierces the diaphragm, and ends in the renal plexus. It is often absent, and then its place is taken by one or more filaments from the small splanchnic nerve. To obtain a proper view of this minute nerve, the diaphragm should be

divided over its course, but this can only be done in cases where the dissector of the abdomen has completed his examination of the diaphragm.

Thoracic Wall.—The thoracic wall should now be studied from within. Certain facts which have previously been stated regarding it can now be verified (*vide* p. 178). The *internal intercostal* muscle, in each space, will be seen to extend backwards as far as the angles of the ribs. At this point it stops abruptly, but the external intercostal muscle is not exposed to view. It is covered on its deep aspect by the posterior intercostal membrane, the connections of which can now be ascertained.

The *posterior intercostal membrane* is a strong aponeurotic layer which is continuous internally with the outer margin of the superior costo-transverse ligament, and extends outwards upon the deep surface of the external intercostal muscle. At the inner margin of the internal intercostal muscle it passes between the two intercostal muscular strata and is gradually lost. The intercostal vessels and nerve extend outwards upon its anterior aspect under cover of the pleura.

The *subcostal muscles* are also displayed. They are small fleshy fasciculi placed upon the ribs, internal to their angles. The muscular fibres which compose them have the same direction as the internal intercostal muscles. They extend over one or, in many cases, two intercostal spaces.

Remove the posterior intercostal membrane from one or two of the spaces, and the subjacent *external intercostal* muscles will be brought into view. These muscles reach backwards as far as the tubercles of the ribs.

Intercostal Arteries and Nerves.—The *aortic intercostal arteries* have already been seen taking origin from the thoracic aorta. One is given to each of the nine lower intercostal spaces upon both sides of the body. As the

aorta lies somewhat to the left of the middle line, the *right* aortic intercostal arteries are longer than those of the left side. In both cases they run outwards over the bodies of the vertebræ, and under cover of the gangliated cord of the sympathetic. On the right side, the arteries also pass under cover of the œsophagus, the thoracic duct, and the vena azygos major. As they leave the vertebral column to enter the intercostal spaces, each of the vessels gives off a large *dorsal branch* which passes backwards in the interval between the transverse processes and is distributed to the muscles and skin of the back. From this branch a *spinal twig* is supplied through the intervertebral foramen to the spinal cord and its membranes. In each space, the intercostal artery proceeds outwards, first lying between the posterior intercostal membrane and the pleura, and afterwards between the two muscular strata. Each artery is accompanied by a nerve and a vein. The vein usually occupies the *highest* level, the nerve the *lowest* level, whilst the artery is *intermediate*. The distribution of these vessels in the thoracic parietes has already been studied (*vide* p. 181).

The position of the intercostal artery in the intercostal space is a matter of some surgical importance. At first it crosses the intercostal space obliquely, so as to gain the shelter of the subcostal groove of the rib which bounds the space above. It attains this position near the angle of the rib, and as it proceeds forwards the groove affords it a very efficient protection against wounds from without.

The intercostal arteries which supply the *two highest* intercostal spaces, are derived from the *superior intercostal* artery of the subclavian. The superior intercostal artery descends upon the necks of the first two ribs, and external to the gangliated cord. It anastomoses with the first aortic intercostal artery, and sends outwards two vessels for the two highest spaces. Each of these, in turn, gives off a *dorsal branch* similar to the dorsal branches of the aortic intercostal arteries.

The *intercostal nerves* pass outwards in company with the arteries. The communicating twigs which pass between these nerves and the sympathetic ganglia have already been noted. Each nerve lies at a lower level than the corresponding artery, and is at first placed between the posterior intercostal membrane and the pleura, and then between the two muscular strata. The further course of these nerves is described at p. 179.

The *first dorsal* nerve will be found passing upwards over the neck of the first rib to join the brachial plexus. It gives a small branch to the first intercostal space, but this nerve, although it is disposed after the manner of an intercostal nerve, does not furnish, as a rule, a lateral cutaneous branch. The *second dorsal* or *intercostal* nerve very frequently sends a branch upwards over the neck of the second rib, to join that portion of the first dorsal nerve which enters the brachial plexus (Fig. 9, p. 43). As a general rule, this communicating twig is exceedingly minute and insignificant, but sometimes it is a large nerve; and, in these cases, the intercosto-humeral nerve, or lateral cutaneous branch of the second intercostal nerve, is very small or altogether absent.

Veins of the Thoracic Wall.—When the dissector has traced the *intercostal veins* to their various destinations, he will find that they differ in their arrangement upon the two sides of the body. On the *right side* they terminate in three different ways:—

1. The intercostal vein of the first or highest space joins the *right innominate vein* (sometimes the *vertebral vein*).
2. The intercostal veins of the second and third spaces (and sometimes of the fourth space) unite into a common trunk, which joins the upper part of the *vena azygos major*. The common trunk is termed the *superior intercostal vein*.
3. The intercostal veins of the eight lower spaces join the *vena azygos major*.

On the *left side* of the body *four* modes of termination may be recognised :—

1. The intercostal vein of the first or highest space has the same termination as the corresponding vein of the right side. It joins the *left innominate vein* (sometimes the *vertebral vein* of its own side).
2. The intercostal veins of the second and third spaces (and sometimes of the fourth space) converge, and by their union form a single trunk, termed the *superior intercostal vein*, which crosses the arch of the aorta and joins the *left innominate vein* independently of the first intercostal vein (p. 211).
3. The intercostal veins of the fourth, fifth, sixth, seventh, and eighth spaces terminate in the *vena azygos minor superior*.
4. The intercostal veins of the ninth, tenth, and eleventh spaces join the *vena azygos minor inferior*.

The azygos veins which thus receive the blood of the great majority of the intercostal veins should now be studied.

Vena Azygos Major.—This vein takes origin within the abdomen in some of the ascending branches of the right lumbar veins. It also frequently communicates with the right renal vein. It enters the thorax through the aortic opening of the diaphragm, lying upon the right side of the thoracic duct and the aorta. In the thorax it extends upwards upon the bodies of the dorsal vertebræ and over the right intercostal arteries, until it reaches the level of the upper border of the root of the right lung. At this point it hooks forwards over the right bronchus, and ends by joining the superior vena cava. It is situated in the posterior mediastinum, with the aorta lying to the left and the thoracic duct occupying the interval between them (Figs. 53 to 56).

The *tributaries* of the vena azygos major are as follows: —(1) the superior intercostal vein of the right side; (2) the intercostal veins of the eight lower spaces of the right side; (3) the vena azygos minor superior; (4) the vena azygos minor inferior; (5) the bronchial vein from the right lung; (6) certain of the œsophageal veins; (7) some minute pericardiac veins.

The vena azygos major communicates below with some of the lumbar veins—tributaries of the inferior vena cava; whilst above, it pours its blood into the superior vena cava. In this way it forms a link by which the superior vena cava is brought into connection with the inferior vena cava.

Vena Azygos Minor Superior.—This vein is formed on the left side of the body by the union of the intercostal veins of the fourth, fifth, sixth, seventh, and eighth spaces. It communicates above with the left superior intercostal vein, which carries the blood from the second and third intercostal spaces to the left innominate vein. At the level of the eighth dorsal vertebra it turns inwards behind the aorta and thoracic duct, and crossing the middle line, it ends by joining the vena azygos major. In many cases, however, it joins the vena azygos minor inferior. In addition to the intercostal veins it receives the left bronchial vein.

The Vena Azygos Minor Inferior.—This vein takes origin within the abdomen by radicles which spring from the lumbar veins of the left side. It enters the thorax by piercing the left crus of the diaphragm, and is continued upwards upon the vertebral column as far as the ninth dorsal vertebra. At this point it turns to the right, and crossing behind the aorta and thoracic duct, it joins the vena azygos major independently of the vena azygos minor superior.

The tributaries of this vein are the intercostal veins of the three lower spaces of the left side.

The veins of the thoracic parietes are extremely variable, and the above description of them must be looked upon as merely representing their most usual arrangement.*

* B. G. Morison, by a large number of dissections, has proved the above arrangement to be the one most commonly met with (vide *Journal of Anatomy and Physiology*, 1879).

THORACIC JOINTS.

The student should now complete the dissection of the thorax by an examination of the various thoracic joints.

Anterior Thoracic Articulations.—The portion of the sternum with the cartilages of the ribs which was laid aside, together with the other joints in connection with the anterior wall of the thorax, should now be dissected. Inter-sternal, costo-sternal, and inter-chondral articulations require examination. Very little dissection is necessary. After the ligaments have been defined, the dissector should remove a thin slice from the anterior aspect of each articulation, in order that the interior of the joint may be displayed.

Seven ribs articulate, by means of their cartilages, directly with each side of the sternum. The articulations of the first and the sixth are peculiar, inasmuch as they articulate with single pieces of the sternum, viz. with the manubrium and the lowest piece of the gladiolus respectively, whereas the cartilages of the other true ribs each articulates with two segments of the sternum. The cartilage of the first rib is implanted upon the side of the manubrium without any synovial membrane, or other material, intervening. The sixth rib is usually separated from the sternum by a single synovial membrane. The remaining costo-sternal articulations have each two synovial membranes separated by an interarticular ligament. There is, however, considerable variety in the articulations of the lower three ribs, and a synovial membrane is frequently wanting in the costo-sternal joints of the sixth and seventh ribs.

The Inter-sternal Articulation between the manubrium and the gladiolus is a synchondrosis. The union is effected by the interposition of a single layer of hyaline cartilage between the bones, and the joint is supported by

some anterior and posterior longitudinal fibres which are developed in connection with the periosteum. The posterior ligament is the stronger of the two. In some cases a synovial fissure may be detected in this joint. The nature of the articulation will be best understood by sawing off a thin slice of the sternum from the front of the joint.

The Costo-sternal Articulations which belong to the diarthrodial variety are provided with anterior, posterior, and interarticular ligaments. The *anterior* and *posterior* ligaments are strong, flattened bands of fibres which radiate from the extremities of the rib-cartilages, and blend with the periosteum on the anterior and posterior surfaces of the sternum. The *interarticular* ligaments are feeble bands which pass from the tips of the rib-cartilages to the sternum, and divide the different articulations into an upper and a lower compartment, each lined by a synovial membrane.

The Inter-chondral Articulations are joints formed between the adjacent margins of the costal cartilages of some of the lower ribs (generally from the fifth or sixth to the ninth). They are protected by capsules formed by strong oblique ligamentous fibres, and are lined by synovial membrane.

Costo-vertebral Articulations.—With the exception of the first and the last three ribs, the head of each rib articulates with the bodies of two vertebræ and the intervening intervertebral substance. The costal head is wedge-shaped, and the socket formed for its reception presents a corresponding form. From the intervertebral disc taking part in the formation of the socket, a certain amount of elasticity is communicated to the joint, and shocks given to the thoracic wall are the more successfully counteracted. The heads of the first, tenth, eleventh, and twelfth ribs are implanted directly upon the bodies of

the corresponding vertebræ. The articulations between the heads of the ribs and the bodies of the vertebræ are termed the *costo-central joints*. But the vertebral extremities of the ribs present another series of articulations. The upper ten ribs, by means of their tubercles, rest upon and articulate with the extremities of the transverse processes of the corresponding dorsal vertebræ. These joints are termed the *costo-transverse articulations*. The eleventh and twelfth ribs have no tubercles, and do not articulate with the transverse processes of the vertebræ with which they are connected.

Costo-central Joints.—These joints belong to the diarthrodial variety, and are provided with—(1) an anterior costo-central ligament; (2) an interarticular ligament; and (3) two synovial membranes. In the case of the four ribs, however, which articulate with the body of one vertebra alone (viz. the first, tenth, eleventh, and twelfth), the joint cavity is single, and the interarticular ligament is absent.

The *anterior costo-central ligament* is placed in front of the joint. It is composed of strong fibres, which radiate in a fan-shaped manner from the head of the rib. It is frequently termed the *stellate ligament*. Its vertebral attachment is effected by three, more or less distinct slips —(1) the uppermost, which is the largest, passes upwards and inwards to the body of the vertebra, which forms the upper part of the socket for the head of the rib; (2) the middle slip is attached to the intervertebral disc; and (3) the lowest slip goes to the body of the vertebra below the head of the rib.

In the four costo-central joints, where the head of the rib is in contact with the body of one vertebra, the stellate ligament is composed of only two slips. Of these, the *lower* is attached to the body of the vertebra which supports the rib, whilst the *upper* passes upwards to the lower border of the vertebral body immediately above.

The *interarticular ligament* may be exposed by removing the stellate ligament from the front of the joint. It is composed of short strong fibres which are attached, on the one hand, to the ridge between the two articular facets on the head of the rib, and on the other hand to the intervertebral disc. It divides the joint into two synovial cavities, and it is absent in those cases in which the head of the rib articulates with the body of one vertebra.

The *synovial membranes* are two in number, except in the costo-central joints of the first and last three ribs. One is placed above, and the other below, the interarticular ligament.

The Costo-transverse Articulations are provided with capsular ligaments, and with superior, middle, and posterior costo-transverse ligaments. Each joint-cavity is lined by a synovial membrane.

The *superior costo-transverse ligament* (anterior or long) passes obliquely downwards and inwards from the lower border of the transverse process to the upper border of the neck of the rib next below it. Its internal margin is thick and well defined, and its outer border becomes continuous with the posterior intercostal membrane. It is absent in the articulation of the first rib.

The *middle* or *interosseous costo-transverse ligament* consists of fibrous bands which pass between the neck of the rib and the anterior surface of the transverse process against which it rests. The fibres of this ligament are so short that it is exceedingly difficult to obtain a proper view of them. The best plan is to saw off, in a horizontal direction, the upper parts of the neck of the rib and the transverse process to which it is attached.

The *posterior costo-transverse ligament* is a strong flattened band which passes, on the posterior aspect of the joint, from the tip of the transverse process to the rough portion of the tubercle of the rib.

The posterior costo-transverse ligament, supplemented

by a few fibres which surround the synovial membrane of the joint, forms the *capsular ligament.* When the posterior costo-transverse ligament is removed the *synovial membrane* is displayed.

Intervertebral Articulations.—The *bodies* of the vertebræ are held together by a series of amphiarthrodial joints, supported in front by an anterior common ligament, and behind by a posterior common ligament. The *neural arches*, by means of the articular processes, form a series of diarthrodial joints surrounded by capsular ligaments, and lined by synovial membranes. Certain ligaments pass between different portions of the neural arches and their processes, viz. the ligamenta subflava between adjacent laminæ, the inter-transverse, the inter-spinous, and the supra-spinous ligaments.

The laminæ and the spinous processes of the vertebræ have been removed by the dissector of the head and neck in opening up the spinal canal to display the spinal cord. Consequently, the ligamenta subflava, the inter-spinous and supra-spinous ligaments, cannot be seen at present. They are described in the volume treating of the Head and Neck, p. 352.

The *anterior common ligament* is situated in front of the bodies of the vertebræ, and extends from the axis vertebra above to the first piece of the sacrum below. It consists of stout glistening fibrous bands, which are firmly attached to the margins of the vertebral bodies and to the intervertebral discs. The most superficial fibres are the longest, and extend from a given vertebra to the fourth or fifth below it. The deeper fibres have a shorter course, and pass between the borders on two, three, or four adjacent vertebræ. The dissector cannot fail to notice that the origin of the longus colli muscle is inseparably connected with this ligament.

The *posterior common ligament* is placed on the back of the vertebral bodies, and therefore within the spinal canal.

It is firmly connected to the margins of the vertebral bodies, and to the intervertebral discs, but is separated from the central parts of the bodies by some loose connective tissue and by a plexus of veins. It is constricted where it covers this venous plexus, but widens out opposite the intervertebral discs. It therefore presents a scalloped or denticulated appearance.

The *intervertebral substance* is disposed in a series of flattened discs which correspond in outline to the vertebræ between which they are situated. The peripheral part of each disc is tough and fibrous; the central portion soft and pulpy. In a transverse section the peripheral portion appears concentrically laminated : in a vertical section the most peripheral laminæ are seen to be bent with the convexity turned away from the centre of the disc, the most central laminæ to be bent in the opposite direction, and the intermediate laminæ to be nearly straight. It will be easily seen that this remarkable arrangement increases the elasticity of the spine, and tends to restore it to its natural curvature after it has been deflected by muscular action.

The intervertebral discs constitute the main bond of union between the bodies of the vertebræ, but, except in old people, they are not directly attached to the bone. A thin layer of encrusting cartilage coats the opposing vertebral surfaces. Vertical and transverse sections must be made through two or more of the intervertebral discs, in order that their structure may be displayed.

The facets of the *articular processes* are coated by hyaline cartilage. A capsular ligament lined by a synovial membrane encloses each joint.

The *intertransverse ligaments* are feeble bands which pass between the tips of the transverse processes. In the lower part of the dorsal region they are intimately blended with the intertransverse muscles : in the middle and upper parts of the dorsal region they entirely replace the muscles.

INFERIOR EXTREMITY.

LOWER LIMB.

On the morning of the third day, after the subject is brought into the Rooms, it is placed upon the table with its face downwards and its chest and pelvis supported with blocks (Fig. 1, p. 3). In this position it is allowed to remain for *four* days, and during this time the dissector of the lower limb has a very extensive dissection to perform. He has to dissect—(1) the gluteal region; (2) the popliteal space; and (3) the back of the thigh. With so much work before him, and being limited as to the time in which it must be done, it is very necessary that he should apportion the four days at his disposal so as to be ready for the turning of the body. The *first two days* he should devote exclusively to the study of the gluteal region; the *third day* may be given to the popliteal space; and on the *fourth day* he should undertake the dissection of the back of the thigh, and revise the work of the three preceding days.

GLUTEAL REGION.

Surface Anatomy.—Before the skin is reflected, the surface markings of the gluteal region require examination. On each side, the prominence of the nates is seen to form a round, smooth elevation. Below, the nates are separated, in the middle line, by a deep fissure, the *natal cleft*. This cleft, if traced upwards, almost disappears over the prominence formed by the coccyx and lower part of the sacrum, but it lies in the same line as the mesial groove of the back. The crest of the ilium can be felt along its whole

length, and, except in very obese subjects, appears as a groove—the *iliac furrow*. In front, it can be readily seen to terminate in the anterior superior spine of the ilium, but behind, the posterior spine of the ilium is obscured on account of the articulation between the ilium and the sacrum. A slight depression, however, indicates the position of the posterior superior spine. The elevation of the nates is formed chiefly by the gluteus maximus muscle, but in front the gluteus medius and tensor fasciæ femoris muscles also take part in its formation. The tensor fasciæ femoris gives rise to a slight elevation below the anterior part of the crest of the ilium. The fold of the nates (*gluteal sulcus*) is a transverse fold of the skin and fascia, and is sometimes stated to correspond with the lower border of the gluteus maximus. This, however, is not the case. It is continuous internally with the groove between the inner side of the thigh and the perineum, and extends outwards below the ischial tuberosity towards the lower part of the great trochanter. "It usually reaches about half way across the back of the thigh, and gradually disappears as it passes outwards: occasionally there are one or more transverse folds below it. Close to the middle line the gluteal sulcus will be found, in an average adult, three or four inches below the gluteus maximus muscle; but, owing to the lower border of the muscle inclining downwards and outwards, while the gluteal fold extends transversely outwards, the two meet a little external to the middle of the lower border of the muscle, and then the fold passes on to the posterior surface of the muscle. The outer end of the lower border of the muscle reaches two or three inches lower down than the outer end of the gluteal fold."—(*Symington.*) The tuberosity of the ischium may be felt below the lower border of the gluteus maximus by placing the fingers in the inner part of the fold of the nates and pressing upwards. A line drawn from the most prominent part of this tuberosity to the anterior superior spine of the ilium is called *Nelaton's line*. This line passes over the

top of the great trochanter and crosses the centre of the acetabulum. It is useful, therefore, as a guide to the proper position of the hip-joint in reducing dislocations. The great trochanter of the femur may be felt at a point about six inches below the highest part of the crest of the ilium. It can be seen in thin subjects, but it is not very prominent. It is covered by the lower parts of the three gluteal muscles.

In this region we have the following parts to dissect and examine after the skin has been reflected :—

1. Superficial fascia.
2. Cutaneous nerves and blood-vessels.
3. Deep fascia.
4. The gluteus maximus: (and after this has been reflected),
5. Three synovial bursæ.
6. Gluteus medius and minimus.
7. Pyriformis.
8. The two gemelli and the tendon of the obturator internus.
9. The tendon of the obturator externus.
10. The quadratus femoris.
11. Upper border of the adductor magnus.
12. The origin of the hamstrings from the tuberosity of the ischium.
13. The upper part of the vastus externus.
14. The great sacro-sciatic ligament.
15. Blood-vessels, { Gluteal. Sciatic. Pudic. Obturator. Internal circumflex. }
16. Nerves. . . { Superior gluteal. Great sciatic. Small sciatic. Pudic. Nerve to obturator internus. Nerve to quadratus femoris. Special branches to gluteus maximus (inferior gluteal nerve). }

Supposing that *two days* are allowed for the above dissection, the **first day's work** should consist—(1) in the

dissection of the parts superficial to the gluteus maximus; (2) in the cleaning and reflecting of this muscle; (3) in tracing and defining the various nerves and blood-vessels which enter its deep surface. **On the second day** the parts which are exposed by the reflection of the gluteus maximus should be dissected.

Reflection of Skin.—*Incisions.*—(1) From the posterior superior spine of the ilium in a curved direction outwards, following the crest of the ilium, as far forwards as the position of the body will permit; (2) from the posterior extremity of this curved incision obliquely downwards and inwards to the middle line of the sacral region, and then perpendicularly downwards to the tip of the coccyx; (3) from the tip of the coccyx obliquely downwards and outwards over the back of the thigh. When properly carried out, this incision intersects the fold of the nates at about its middle point, and terminates a little below the upper third of the thigh (Fig. 1, p. 3).

A large flap of skin is thus marked out, and this must be raised from the subjacent superficial fascia and thrown outwards. On the right side of the body, the dissector begins at the crest of the ilium and works downwards and forwards; whilst on the left side he commences over the coccyx and works upwards and forwards.

Superficial Fascia.—The superficial fascia is now exposed, and it is seen to partake of the same characters as the corresponding layer of fascia in other parts of the body. Notice, however, its special peculiarities in this region. How it is much more heavily laden with fat—especially in the female; how it thickens over the lower and upper margins of the gluteus maximus, and how it becomes tough, elastic, and stringy over the ischial tuberosity, so as to form a most effective cushion upon which this bony prominence may rest while the body is in the sitting posture.

Cutaneous Nerves.—The superficial fascia forms a bed in which the cutaneous nerves ramify before they enter the skin. In this region the cutaneous nerves are very numerous, and they are derived from a great variety of sources. Some proceed from the *posterior* primary divisions of the spinal nerves, whilst others are branches of the *anterior* primary divisions of the spinal nerves.

From the *posterior primary divisions* there are usually *six*—*three* from the *sacral* nerves, and three from the *lumbar* nerves. The *three sacral nerves* reach the surface by piercing the gluteus maximus muscle close to its origin from the sacrum and coccyx. They pierce the muscle in a line drawn from the posterior superior iliac spine to the tip of the coccyx. The largest is found opposite the lowest piece of the sacrum, the highest about an inch above this, and the lowest about the same distance below it. Owing to the coarseness of the muscular fasciculi between which they appear, they are somewhat difficult to find. In looking for them, it is best to cut right down through both superficial and deep fasciæ, so as to secure them as they emerge from the muscle.

The *three lumbar nerves* are easily found. They cross the crest of the ilium at a point corresponding to the outer limit of the attachment of the erector spinæ to the innominate bone. They pass downwards and outwards in the superficial fascia, and run in different planes, the larger trunks being placed deeper than the smaller branches. They communicate with one another and with the sacral nerves. A few twigs may be followed as far as the great trochanter.

The cutaneous twigs which come from the *anterior primary divisions* of the spinal nerves may be classified under three headings—(1) those which pass downwards over the crest of the ilium; (2) those which pass backwards over the insertion of the gluteus maximus into the fascia lata; (3) those which turn upwards around the lower margin of the gluteus maximus.

The nerves which cross the crest of the ilium are—(1) the *iliac branch* of the *ilio-hypogastric* nerve; and (2) the *iliac branch* (*i.e.* the lateral cutaneous branch) of the *last dorsal* nerve.

The *iliac branch* of the *ilio-hypogastric* nerve pierces the

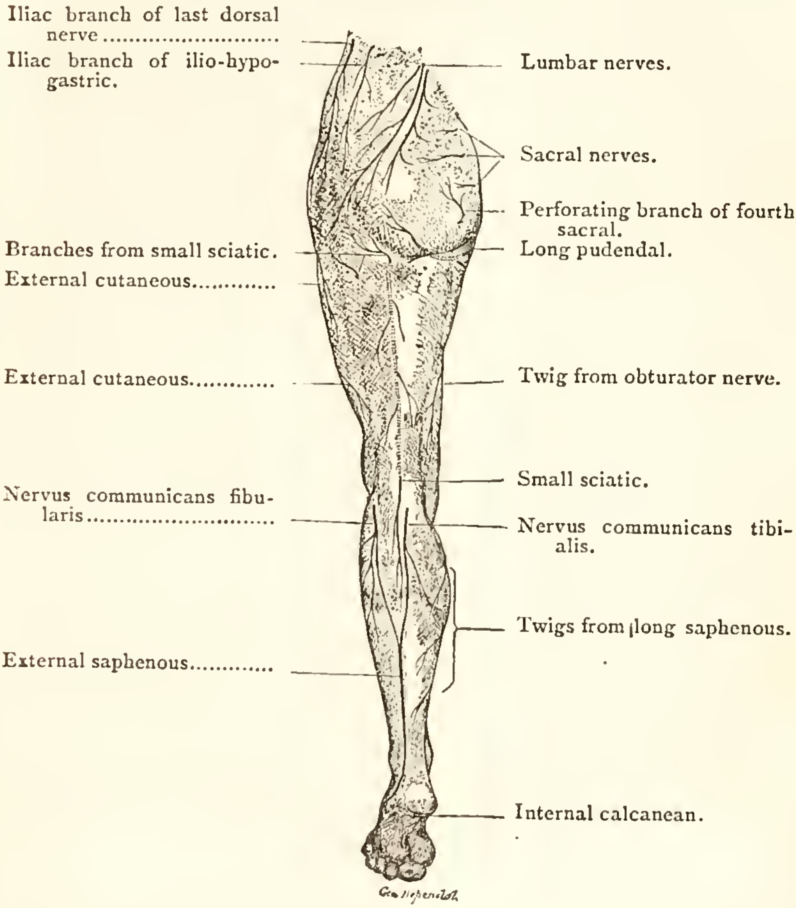

FIG. 58.

Cutaneous Nerves on the back of the Lower Limb.

external oblique muscle at its attachment to the ilium. It usually crosses the iliac crest opposite a tubercle which projects from the outer lip of the crest about two and a half inches from the anterior superior spine, but it may emerge

at any point between this tubercle* and the anterior border of the iliac origin of the latissimus dorsi.

The *iliac branch* of the *last dorsal* nerve pierces the external oblique a short distance in front of the ilio-hypogastric branch, at a point situated one to two inches above the crest. Both nerves, after crossing the iliac crest, run downwards and outwards in the thick superficial fascia over the upper part of the gluteus medius, and spread out into a great number of fine twigs, which ramify over the insertion of the gluteus maximus; some of them reach downwards as far as the level of the great trochanter.

The nerves which pass backwards over the insertion of the gluteus maximus are a few small branches of the posterior division of the *external cutaneous nerve* of the thigh. They are found above the level of the great trochanter.

The cutaneous twigs which hook round the lower margin of the gluteus maximus muscle, to reach the skin over this region, are a few offsets from the *small sciatic nerve* and the *perforating cutaneous branch* of the *fourth sacral nerve.* The former appear external to the tuberosity of the ischium, and are accompanied in some cases by twigs from the sciatic artery. The latter comes into view internal to the ischial tuberosity, and is accompanied by small branches of the inferior hemorrhoidal artery. These nerves can most readily be found by everting the lower border of the gluteus maximus; but in doing this, care must be taken to avoid injury to the trunk of the small sciatic nerve, which passes from under cover of the gluteus maximus and runs vertically down the thigh.

The Deep Fascia, in the next place, claims the attention of the dissector. This is brought into view by removing the remnants of the superficial fascia. Observe the marked

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* This tubercle may be very prominent, and is sometimes (in the present position of the body) mistaken by the junior student for the anterior superior spine of the ilium.

contrast between the fascia covering the gluteus maximus and that clothing the anterior exposed portion of the gluteus medius. Over the gluteus maximus, except at its insertion, the deep fascia is present in the form of a thin transparent layer, through which the muscular fibres are plainly visible, whilst over the gluteus medius it constitutes a strong, opaque, pearly-white aponeurosis, which is firmly attached by its upper limit to the crest of the ilium. The dissector will notice that the fascia which conceals the insertion of the gluteus maximus is of the same character as that covering the gluteus medius (of which it is a direct continuation). In a well-injected subject, a number of arterial twigs will be seen piercing this portion of the fascia. These are derived from the first perforating branch of the profunda.

Gluteus Maximus.—Now proceed to clean this muscle. If it is the right limb, begin at the anterior or upper margin of the muscle; but if it is the left, commence the dissection at the posterior or lower border. In undertaking this dissection, the dissector must keep clearly before him the rules which have already been laid down regarding the cleaning of a muscle:—(1) render the fibres as tense as possible by rotating the limb *inwards*; (2) remove the fascia in one continuous layer; (3) always cut in the direction of the muscular fibres, which in this case corresponds with a line drawn from the sacrum to the great trochanter; (4) define very carefully the borders of the muscle.

The gluteus maximus is a difficult muscle to clean, the fasciculi are so exceedingly coarse. To do it well, it is not sufficient to remove the fascia which covers the muscle, but it is necessary at the same time to follow, for a short distance, the septa which penetrate between the fasciculi, and to remove them also. Do not remove the thick opaque fascia which covers the insertion of the muscle.

The dissector of the left limb, on reaching the anterior margin of the muscle, will observe that the fascia which he holds in his hand is continuous with the strong aponeurosis which covers the gluteus medius; and further, if he now frees the anterior border of the muscle from subjacent parts, he will notice that the layer of fascia upon which the gluteus maximus rests is also continuous with the same aponeurosis. In other words, he will in this manner be able to satisfy himself that the strong fascia which covers the anterior part of the gluteus medius splits into two layers to enclose the gluteus maximus. Let him now follow these two layers downwards and outwards, and he will see that the upper part of the muscle is inserted between them, and that the deeper, as well as the more superficial layer, is thickened in this situation. The small sciatic nerve lies in very close relation to the deep surface of the muscle, and is apt to be injured in the subsequent steps of the dissection, unless it is secured at once by everting the lower border of the muscle.

The Gluteus Maximus arises from a narrow, rough area on the dorsum ilii, which is included between the superior curved line and the outer lip of the crest; from the corresponding portion of the crest itself; from the sides of the lower two pieces of the sacrum and the upper three pieces of the coccyx; from the entire posterior surface of the great sacro-sciatic ligament; and slightly from the posterior layer of the lumbar aponeurosis, at the attachment of the latter to the crest of the ilium. It also derives a few fibres of origin from the deep layer of fascia which lies between it and the gluteus medius. From this extensive origin the fibres proceed downwards and outwards, and, converging slightly, are inserted as follows:—The upper fibres, corresponding to about two-thirds of the entire muscle, end in the deep fascia, or fascia lata, in the manner described above; the lower fibres are inserted into a rough line on the femur, which extends from the great trochanter to the linea aspera: a few of the lowest fibres pass into the upper

extremity of the external intermuscular septum of the thigh.

Reflection of Gluteus Maximus.—This is the next step in the dissection of this region, and it is one which demands the utmost care upon the part of the dissector, owing to the close connexion of the muscle with important structures which lie subjacent to it.

If the subject be obese, or the muscle thick and heavy, it should be thrown down from above by dividing it close to its origin, but if the body be thin and spare, a much better result will be obtained by carrying out the following dissection:—Rotate the limb outwards, and enter the knife at the upper border of the muscle immediately above its insertion. First cut through the strong fascia lata in the direction of the upper border of the muscle, and then carry the knife directly downwards through the deep fascia into which the upper part of the muscle is inserted. In dividing this fascia, care should be taken not to injure the subjacent gluteus medius. The tensor fasciæ femoris, also, is liable to injury if the incision be carried too far forwards. The strong, shining, aponeurosis which covers the upper part of the vastus externus will now come into view. It is separated from the insertion of the gluteus maximus by a *synovial bursa.* A more important *bursa* will be seen in relation to the great trochanter. It is of very large size, and is directly interposed between the muscle and the external surface of the bone. Open it with the knife, and estimate its extent by introducing the finger. Note the thinness of its walls, and further, that it usually consists of one sac. Next examine, in a similar manner, *the bursa* in connection with the tuber ischii. It will be found upon the inferior aspect of this prominence, and the dissector will not fail to observe that it lies more between the tough superficial fascia and bone than between the muscle and bone. Now pass the fingers under the insertion of the gluteus maximus, in order to isolate it completely from other structures (especially from the

small sciatic nerve), and divide it about two inches from its attachment to the femur. The insertion of the gluteus maximus may now be accurately defined, and it will be found adherent, externally to a part of the vastus externus below the bursa, and internally to the adductor magnus, and in this situation the first perforating artery will be seen piercing the adductor magnus, and sending terminal twigs through the gluteus maximus.

Now turn the gluteus maximus muscle upwards towards its origin, and numerous blood-vessels and nerves are displayed, sinking into its substance. The arteries are—(1) the *superficial* division of the *gluteal artery;* and (2) branches of the *sciatic artery.* The nerves are—(1) some special branches of the sacral plexus (*inferior gluteal nerve*); and (2) a few twigs from the *small sciatic nerve.* The veins may be at once removed, but the arteries and nerves must be systematically and thoroughly cleaned as they come into view: by doing this they will stretch sufficiently to allow the muscle to be fully reflected. The origin of the gluteus maximus from the great sacro-sciatic ligament must be carefully detached from below upwards. During this dissection, numerous twigs from the *ramus coccygeus* of the sciatic artery, and the *perforating cutaneous nerve* from the *fourth sacral*, will be seen piercing the ligament: the former will necessarily be cut. The latter has been seen in the superficial dissection turning round the lower border of the gluteus maximus, to supply the integument over the lower and back part of that muscle.

If it is decided to throw the muscle down from above, cut cautiously through its origin close to the iliac crest until some arterial twigs make their appearance; follow these twigs through the muscular fibres to the main trunks which lie under cover of the muscle. At the same time secure the nerves of supply to the gluteus maximus. After these vessels and nerves have been carefully cleaned and isolated, they must be cut, in order to allow the muscle to be fully reflected.

Parts under cover of the Gluteus Maximus.—On the **second day** the dissector undertakes the dissection of the remaining structures which are displayed by the reflection of the gluteus maximus. The vessels and nerves which have been partially exposed in the previous day's dissection must now be followed up to their points of exit from the pelvis, and the remaining vessels and nerves, together with the muscles, must be defined and cleaned by removing the loose areolar tissue which covers and passes in between them. The following muscles will be recognised as we pass from above downwards:—(1) the gluteus medius; (2) the pyriformis, issuing from the pelvis through the great sacro-sciatic foramen; (3) the tendon of the obturator internus, with the gemellus superior attached to its upper border, and the gemellus inferior to its lower border; (4) the quadratus femoris; (5) the upper border of the adductor magnus. By separating the quadratus femoris from the gemellus inferior, the tendon of the obturator externus will be revealed as it passes round the neck of the femur to reach the digital fossa. Lastly, the origin of the hamstring muscles from the tuber ischii, and the upper part of the vastus externus in relation to the root of the great trochanter, should be noted.

In each interval formed by the adjacent margins of these muscles, blood-vessels and nerves, or blood-vessels alone, are to be found. Before proceeding to the dissection of these, however, it is well that the student should renew his acquaintance with the skeletal peculiarities of this region. Let him obtain a dried pelvis with the ligaments *in situ*, and study carefully the position and boundaries of the great and small sciatic notches, and how they are converted into foramina by the small and great sacro-sciatic ligaments. Through these foramina most important structures issue from the interior of the pelvis into the gluteal region.

With the knowledge thus acquired, let the student return to his dissection and dissect out the blood-vessels and nerves of the region.

Gluteal Artery and Superior Gluteal Nerve.—In the

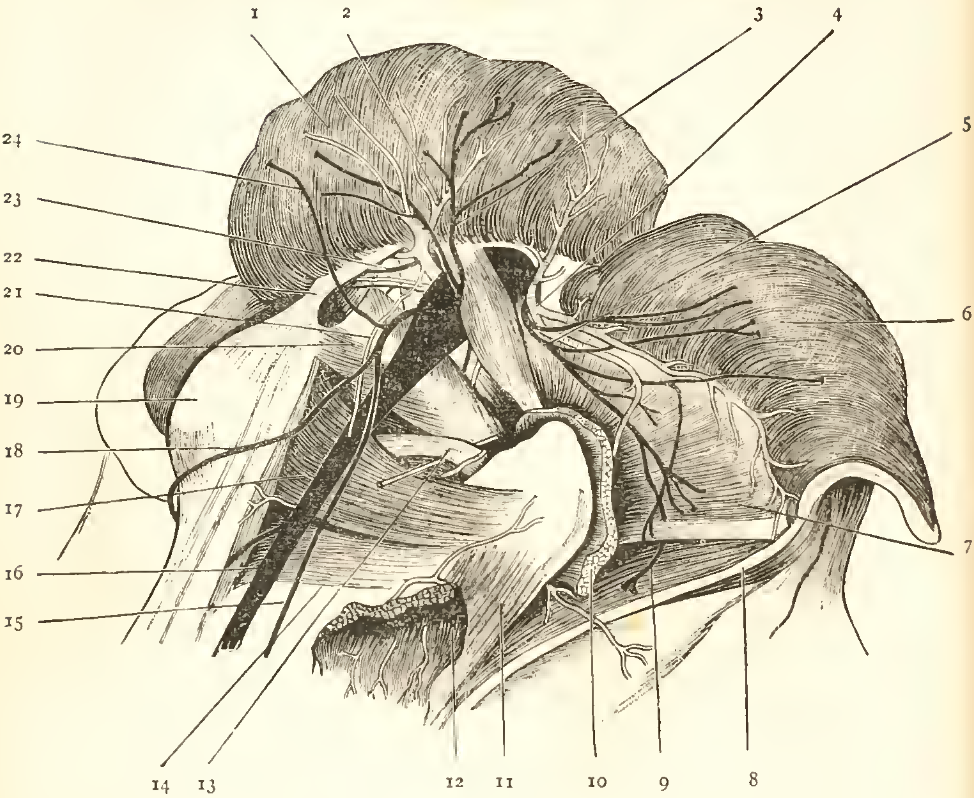

FIG. 59.

Dissection of Gluteal Region. The Gluteus Maximus and Gluteus Medius have been thrown upwards.

1. Gluteus maximus.
2. Sciatic artery.
3. Inferior gluteal nerve.
4. Gluteal artery.
5. Superior gluteal nerve.
6. Gluteus medius.
7. Gluteus minimus.
8. Tensor fasciæ femoris.
9. Branch from superior gluteal nerve to the tensor fasciæ femoris.
10. Tendon of gluteus medius.
11. Vastus externus.
12. Tendon of gluteus maximus.
13. Obturator externus.
14. Upper part of adductor magnus.
15. Small sciatic nerve.
16. Great sciatic nerve.
17. Quadratus femoris.
18. Long pudendal nerve.
19. Tuber ischii.
20. Obturator internus tendon with the gemelli.
21. Arteria comes nervi ischiadici.
22. Great sacro-sciatic ligament.
23. Internal pudic nerve.
24. Branch from small sciatic nerve to gluteus maximus.

interval between the pyriformis and the gluteus medius,

the gluteal artery and the superior gluteal nerve will be seen to emerge from the pelvis through the great sacro-sciatic foramen. The artery at once divides into a *superficial* and a *deep* division. The distribution of the former has already been noted. It has been seen to sink into the deep surface of the gluteus maximus and to supply the upper part of that muscle.

The *superior gluteal nerve* and the *deep division* of the gluteal artery are distributed under cover of the gluteus medius. Their distribution will be studied after this muscle has been reflected.

In the interval between the pyriformis and superior gemellus, *two* arteries, with their accompanying veins and *six* nerves, issue from the lower part of the great sacro-sciatic foramen.

Arteries,
1. Sciatic.
2. Internal pudic.

Nerves,
1. Great sciatic.
2. Small sciatic.
3. Internal pudic.
4. Nerve to the obturator internus.
5. Nerve to the quadratus femoris.
6. Special nerve to the gluteus maximus (inferior gluteal).

Sciatic Nerves and Vessels.—The *sciatic artery* divides into several branches, almost immediately after its emergence from the great sciatic notch. Of these, the large muscular offsets to the gluteus maximus, and the cutaneous twigs that accompany the branches of the lesser sciatic nerve which turn round the lower border of that muscle, have been already studied. The following three branches remain to be examined:—(1) the *coccygeal* branch which passes inwards between the greater and lesser sacro-sciatic ligaments, to reach the integument and fascia in the region of the coccyx: a number of twigs derived from this branch have been previously noticed piercing the

greater of the two ligaments and ending in the gluteus maximus; (2) the *comes nervi ischiadici*, a minute artery, which runs downwards on the great sciatic nerve and finally penetrates into its substance; (3) the *artery to the quadratus femoris*, which accompanies the nerve to that muscle, and will be found lying on the innominate bone under cover of the great sciatic nerve.

In a well-injected body the anastomosis between the sciatic artery and the internal circumflex, as it appears between the contiguous borders of the adductor magnus and quadratus femoris, may be made out.

The *small sciatic nerve* arises from the sacral plexus within the pelvis. After escaping through the great sacro-sciatic foramen it supplies a few twigs to the lower part of the gluteus maximus, and some branches to the skin over the corresponding part of the same muscle. These have been already studied. While under cover of the lower part of the great gluteal muscle it gives off a few cutaneous twigs to the skin on the inner aspect of the thigh and the long pudendal nerve of Soemmerring. The latter must be followed towards the perineum. It passes inwards, and winds round the origin of the hamstring muscles, just below the ischial tuberosity. At the lower border of the gluteus maximus the small sciatic nerve leaves the gluteal region, and proceeds vertically down the thigh. It will afterwards be traced to the calf of the leg.

The *great sciatic* nerve is the direct termination of the sacral plexus, and is the largest nerve in the body. It has, at first, the form of a flattened band, but soon becomes oval or round in section. The part exposed in the present dissection lies from above downwards on the following structures:—the innominate bone (at the lower margin of the great sciatic notch), the gemellus superior, the tendon of the obturator internus, the gemellus inferior, the quadratus femoris, and the adductor magnus. In this course it does not as a rule give off any branch, but occasionally the nerves to one or more of the hamstring

muscles issue from the main trunk as high as the level of the quadratus femoris.

The great sciatic nerve frequently escapes from the pelvis in the form of two trunks, which enclose between them a portion of the pyriformis muscle.

Dissection.—The student should flex the knee and raise it on a block in order to relax the great sciatic nerve. By pulling this great nerve-trunk outwards, the dissector will expose the nerve to the quadratus femoris lying directly upon the bone. Internal to this he will find the pudic vessels and nerve with the nerve to the obturator internus crossing the spine of the ischium. These structures require to be very carefully cleaned. The twig from the nerve to the obturator internus to the gemellus superior is especially liable to injury. The dissection will be improved by scraping off the periosteum from the small area of bone which is in relation to the above-mentioned vessels and nerves.

The Pudic Vessels and Nerve, and the Nerve to the Obturator Internus emerge from the great sacro-sciatic foramen below the pyriformis, and are only exposed in the present dissection for a very short part of their course. They pass out of view by entering the lesser sacro-sciatic foramen. *The nerve to the obturator internus* is placed most externally. It lies on the base of the ischial spine, and furnishes a twig to the gemellus superior. The *internal pudic artery*, with a companion vein on each side, crosses the tip of the spine. The *internal pudic nerve* is placed most internally, and lies on the lesser sacro-sciatic ligament close to its attachment to the spine. In some cases, however, the pudic nerve unites in a plexiform manner with the nerve to the obturator internus, so that the whole, or a part, of it may lie external to the pudic vessels.

The Nerve to the Quadratus Femoris runs vertically downwards upon the innominate bone, and passes suc-

cessively under cover of the following structures:—the great sciatic nerve, the gemellus superior, the tendon of the obturator internus, and the gemellus inferior. It gives off the nerve of supply to the gemellus inferior, and a twig to the hip-joint, and ends by sinking into the deep surface of the quadratus femoris.

Obturator and Internal Circumflex Arteries.—In the interval between the quadratus femoris and gemellus inferior we find the small ascending terminal branch of the *internal circumflex artery*, and sometimes a minute arterial twig from *the obturator artery*. In the interval between the margins of the quadratus femoris and adductor magnus the transverse terminal branch of the *internal circumflex artery* will be discovered.

External Rotator Muscles of the Thigh.—The pyriformis, obturator internus, and gemelli muscles, should next engage the attention of the dissector. The muscular belly of the obturator internus is the property of the dissector of the abdomen, but its tendon should be studied in connexion with the gemelli. The obturator externus and quadratus femoris have been already noted, but their complete examination should be delayed till a later stage of the dissection.

The *pyriformis* arises within the pelvis from the three middle pieces of the sacrum, and slightly from the upper margin of the great sciatic notch. The sacral origin cannot be seen at present, but the iliac origin should be made out. After passing through the great sacro-sciatic foramen, the muscle is directed downwards, outwards, and forwards. Its fibres rapidly converge, and end in a rounded tendon, which crosses the common tendon of the obturator internus and gemelli, and is inserted into a small impression on the highest part of the great trochanter of the femur. It is closely adherent to the obturator tendon for some distance.

The *obturator internus* and *gemelli* together constitute a

tricipital muscle with one intra-pelvic belly (obturator internus), and two extra-pelvic bellies (gemellus superior and inferior). The common tendon of this tricipital muscle is inserted into an impression on the upper part of the great trochanter of the femur immediately in front of the insertion of the pyriformis. The *gemellus superior* arises from the spine of the ischium at the upper margin of the lesser sciatic notch. Its fibres pass outwards along the superior border of the tendon of the obturator internus, and are inserted obliquely into that tendon. The *gemellus inferior* arises from the tuberosity of the ischium at the lower margin of the lesser sciatic notch, and is inserted into the inferior border of the obturator tendon, in a similar manner to the gemellus superior.

The *tendon* of the *obturator internus* should be cut close to its exit from the lesser sciatic foramen, and thrown outwards. It will be seen to consist of four or five tendinous slips united into a flattened band. These constituent tendons appear distinct and rounded when viewed from their deep surface, but are barely distinguishable when seen from their superficial surface. As they glide over the cartilage which coats the lesser sciatic notch, they are partially separated from one another by thin ridges of the cartilage, and are lubricated by a synovial bursa.

The gluteus medius arises from that part of the dorsum ilii which is bounded above by the superior curved line, and the anterior four-fifths of the crest, and below by the middle curved line; it also derives numerous fibres of origin from the strong fascia which covers its upper and anterior part. The fibres converge to form a flattened band, partly fleshy and partly tendinous, which is inserted into an oblique line on the outer surface of the great trochanter of the femur. To obtain a good view of this muscle, it will be necessary to remove the deep fascia which covers its upper part. In performing this dissection care must be taken not to injure the origin of the

tensor fasciæ femoris, as the latter overlaps the anterior fibres of the gluteus medius, and is adherent to them.

The gluteus medius may now be reflected. Rotate the limb inwards, and, after removing the deep fascia, separate the tensor fasciæ femoris from the gluteus medius and minimus, beginning at the level of the great trochanter, and dissecting from below upwards. While doing this be careful to secure the nerve to the tensor fasciæ femoris, which will be seen piercing the anterior border of the gluteus minimus. An artery will also be noticed ramifying on the deep surface of the tensor fasciæ femoris: this is the ascending branch of the external circumflex. The anterior borders of the gluteus medius and minimus are adherent to one another. Commence the separation, therefore, at the posterior border, by introducing the fingers between the two muscles. Having thus completely isolated the gluteus medius, divide it about two inches above its attachment to the femur. A small bursa between the muscle and the upper part of the great trochanter should now be examined, and the exact insertion of the tendon defined. Now return to the larger portion of the gluteus medius and turn it upwards, cleaning the arteries and nerves on its deep surface as they come into view, until the muscle is fully reflected. The gluteus minimus is now revealed, and also the entire distribution of the superior gluteal nerve and the gluteal artery.

The Gluteal Artery escapes from the pelvis by passing through the great sacro-sciatic foramen above the pyriformis. Immediately after its exit it divides into a superficial and a deep division. The *superficial* division has been already seen during the reflection of the gluteus maximus. It is distributed to the deep surface of that muscle, and is placed between it and the gluteus medius.

The *deep division* bifurcates close to its origin into a superior and an inferior branch; both of these lie between the gluteus medius and minimus. The *superior* branch

follows accurately the middle curved line on the dorsum ilii, and at the anterior superior spine terminates by anastomosing with the superficial and deep circumflex iliac arteries, and with the ascending branch of the external circumflex. The latter has already been noticed passing upwards under cover of the tensor fasciæ femoris. The *inferior* branch runs downwards and forwards towards the great trochanter. It gives twigs to the two gluteal muscles between which it lies, and some terminal offsets to the hip-joint.

The Superior Gluteal Nerve emerges from the pelvis in company with the gluteal artery, and passing forwards between the gluteus medius and minimus, gives branches to both these muscles. Its terminal branch pierces the anterior fibres of the gluteus minimus, and ends in the tensor fasciæ femoris.

The Gluteus Minimus arises from the broad area on the dorsum ilii, which is included between the middle and inferior curved lines. The muscular fibres pass gradually into an aponeurotic tendon, which covers the superficial surface of the lower part of the muscle. This tendon narrows as it descends into a flattened band, which is inserted into a special impression on the anterior aspect of the great trochanter. It is intimately connected at its insertion with the capsule of the hip-joint.

Reflection of the Gluteus Minimus.—The last step in the dissection of the gluteal region consists in the reflection of this muscle. It must be detached from its origin and thrown downwards. Three objects are revealed by this dissection—(1) the capsular ligament of the hip-joint; (2) a bursa which intervenes between the tendon of the muscle and the great trochanter; (3) the reflected tendon of the rectus femoris.

The examination of the *capsular ligament* may be postponed until the quadratus femoris is reflected during the

dissection of the back of the thigh. The *synovial bursa* should be opened and examined. The *reflected tendon* of the *rectus femoris* occupies a groove situated just above the upper margin of the acetabulum. It is partially concealed by some fibres of the capsular ligament, which are prolonged upwards over it. It should be cleaned by repeatedly drawing the point of the knife over it in a direction parallel to its fibres.

POPLITEAL SPACE.

Before the muscles on the back of the thigh are disturbed, it is well to dissect the popliteal space. In this way the boundaries of the space are maintained in position during our examination of the structures which lie within it.

The following are the structures which require to be studied in the popliteal space:—

1. Superficial fascia.
2. External saphenous vein.
3. Small sciatic nerve.
4. Politeal fascia.
5. Muscles which bound the space, { Biceps. Semitendinosus. Semimembranosus. Gastrocnemius. Plantaris.
6. The internal and external popliteal nerves and their branches.
7. The popliteal artery and vein and their branches.
8. A few lymphatic glands.
9. A slender branch from the obturator nerve.
10. The popliteus muscle.

A good-sized block should, in the first place, be inserted under the knee, so as to support the limb, and render the muscles which bound the space tense.

In the study of an anatomical space, the structures which we meet with in our dissection should be examined in a definite order. The *coverings* of the space should

first engage our attention; then we should proceed to define *the boundaries;* next we should dissect out and isolate *the contents;* lastly, *the floor* should be cleaned, and the parts entering into its formation recognized.

Surface Anatomy.—The space which lies immediately above the knee-joint, and between the hamstring muscles, is termed the ham. It is depressed when the knee is flexed, but forms a slight prominence when the joint is fully extended. The outer hamstring is formed by the biceps muscle, the inner by the tendons of the semimembranosus and semitendinosus. The last-named tendon can be easily felt through the skin, as it lies on the superficial surface of the semimembranosus. By pressing deeply into the interval between the hamstrings, the (injected) popliteal artery may be felt, and its pulsations can sometimes be distinguished in this situation in the living subject. The lower portions of the sartorius and gracilis muscles are placed internal to, and in front of, the inner hamstring, and can only be recognized from the surface with considerable difficulty. The long saphenous vein, however, is usually seen in this situation. The tendon of the adductor magnus can be readily felt, and should be traced downwards to the adductor tubercle on the inner condyle of the femur. It can be rendered distinct by slightly flexing the knee-joint, and at the same time forcibly abducting the limb. The condyles of the femur may be seen and felt: the internal is the more prominent of the two. The articulation between the femur and the head of the tibia can very seldom be seen, but can always be felt. Below the knee-joint the head of the fibula forms a prominence on the outer side, and, by flexing the knee and pressing deeply between the fibula and the external condyle of the femur, the cord-like external lateral ligament can be distinguished. The external popliteal nerve may be felt as it crosses the outer side of the neck of the fibula, just before it pierces the peroneus longus muscle. The

two heads of the gastrocnemius form prominent objects in muscular subjects.

The back of the thigh presents a smooth, rounded surface. In thin subjects indications of the bellies of the hamstring muscles may be seen.

Reflection of Skin.—*Incisions*—(1) a vertical incision along the middle line of the limb beginning about five inches above, and terminating about four inches below, the bend of the knee; (2) a transverse incision at the upper end of the mesial incision; (3) a transverse incision at the lower extremity of the mesial incision. The two transverse incisions should extend almost half-way round the limb.

Two flaps of skin are thus mapped out, and these must be raised and thrown, the one inwards and the other outwards.

Superficial Fascia—External Saphenous Vein—Branches of Small Sciatic Nerve.—The fatty layer upon which the skin rests is now brought into view, and the cutaneous nerves and vessels must be secured. First look for a small nerve—*a branch of the small sciatic*—which passes downwards over the space near the middle line, and when this is found, dissect out the *external saphenous vein*. This vessel ascends in the middle line of the leg, and on tracing it upwards it will be found to disappear from view by piercing the deep fascia, and entering the lower part of the popliteal space. The *terminal branch* of the *small sciatic nerve* pierces the popliteal fascia at the lower part of the space, and here it will be seen lying close to the external saphenous vein.

Popliteal Fascia.—Great care must be taken in removing the superficial fascia from the deep popliteal fascia. Although thin, the deep fascia possesses considerable strength, owing to the transverse fibres which are interwoven amidst its proper aponeurotic fibres. In removing this fascia the dissector will notice that it is

firmly attached on each side to the tendons of the muscles which bound the popliteal space. Above it is continuous with the fascia lata of the thigh.

Dissection.—In cleaning the muscles which bound the popliteal space there are certain points to be attended to. In the case of the outer head of the gastrocnemius, care must be taken not to remove the *nervus communicans fibularis*, which passes downwards and inwards upon its surface. In the groove between the heads of this muscle will be seen the *nervus communicans tibialis*. Further, the dissector must not overlook the synovial bursa which intervenes between the tendon of the semimembranosus and the inner head of the gastrocnemius. This bursa sometimes communicates with a second synovial sac, which will be brought into view by lifting the inner head of the gastrocnemius from the internal condyle of the femur.

The dissection may be carried forward a little beyond the inner boundary of the space in order to expose the superficial division of the anastomotica artery, the internal saphenous nerve and vein, and the posterior division of the internal cutaneous nerve. The *internal saphenous nerve* accompanied by the *superficial part* of the *anastomotica artery* will be found under cover of the sartorius. They afterwards come to the surface at its posterior border. The *internal saphenous vein* ascends on the surface of that muscle, whilst the *posterior division* of the *internal cutaneous nerve* courses downwards along the posterior border of the same muscle, and comes to the surface a short distance behind the internal saphenous nerve. Properly speaking these structures belong to the thigh, but it is convenient to secure them at this stage. They will be afterwards noticed more fully.

When the boundaries of the space are thoroughly defined and cleaned, *the contents* should be dissected by removing the soft fat which surrounds them. The principal objects within the popliteal space are the *popliteal*

artery and *vein* with their branches. They are placed deeply in the space, and in close contact with each other—the vein being superficial to the artery throughout. The *two popliteal nerves*—external and internal—also traverse the space. With the exception of the small sciatic nerve which descends immediately subjacent to the deep fascia, the *internal popliteal nerve* is the most superficial structure in the popliteal space. It lies over the popliteal vessels and is readily found by separating the adipose tissue in the middle line of the space. The *external popliteal nerve* will be exposed by dissecting along the upper and outer boundary of the space. It lies under shelter of the biceps muscle. In dissecting the popliteal space a mistake is often made in confining the dissection chiefly to the upper part, whereas the work should be carried out over the entire area at the same time. The heads of the gastrocnemius muscle, therefore, should be well separated from each other. It is here that the dissection becomes tedious, because the numerous branches of the nerves and vessels to the muscles on the back of the leg require time and care for their dissection. In cleaning the popliteal artery and vein try to secure the *geniculate branch of the obturator nerve.* It descends in close apposition with the coats of the artery. As the fat is being cleared out from the space the dissector will not fail to observe a few small *lymphatic glands* in relation to the great vessels.

Boundaries.—The popliteal space is diamond-shaped. Above and to the outside it is bounded by the *biceps* muscle; whilst above and to the inside are the tendon of the *semitendinosus* and the *semimembranosus*, the former lying upon the surface of the latter. On the inner side of the knee and in front of the semimembranosus the *sartorius*, *gracilis*, and the tendon of the *adductor magnus*, can be exposed. Below, the space is bounded by the converging heads of the *gastrocnemius*. In the formation of the lower and outer boundary, the outer head of the

gastrocnemius will be seen to be assisted by the small *plantaris muscle.*

The diamond-shaped space on the back of the knee-joint, which is brought into view by dissection, differs widely from the condition which is observed when transverse sections are made through this part of the frozen limb. Before the integuments and fasciæ are removed all the parts are tightly braced together, and the popliteal space is merely represented by a small intermuscular interval between the lower parts of the hamstring muscles where they are separated from each other by the condyles of the femur. The space in this condition is rather under an inch wide at its broadest part. The popliteal artery, therefore, which traverses the space, is covered by muscles throughout its whole course, with the exception of a very small part immediately above the knee-joint.

The Floor of the Space must now be cleaned. Scrape the fatty tissue from the popliteal surface of the femur with the handle of the knife. The floor is formed from above downwards by—(1) the popliteal surface of the femur; (2) the posterior ligament of the knee-joint, and (3) by the strong fascia which covers the popliteus muscle. It is during this stage of the dissection that the articular branches of the popliteal artery are most liable to injury, as they lie in close contact with the floor. Be especially careful not to injure the azygos articular artery which pierces the posterior ligament of the knee-joint, and the superior articular arteries which wind round the femur, immediately above the condyles. The fascia covering the popliteus muscle should be left in position.

The Small Sciatic Nerve enters the popliteal space at its upper angle, and proceeds downwards immediately subjacent to the popliteal fascia. It gives one or two twigs through the fascia to the skin, and finally pierces the fascia in the lower part of the space. Its terminal twigs are distributed to the skin over the upper part of the calf of the leg.

The Internal Popliteal Nerve enters the popliteal space by emerging from under cover of the biceps muscle, and it runs vertically downwards so as to bisect the space

longitudinally. It is one of the two terminal branches of the great sciatic nerve, and it arises a little below the middle of the thigh. At the lower border of the popliteus muscle it becomes continuous with the posterior tibial nerve. The superficial position of the internal popliteal nerve has already been referred to. At first upon the outer side of the popliteal vessels it crosses them superficially, and in the lower part of the space it is placed upon their inner side. Its *branches* may be classified into cutaneous, muscular, and articular.

The *nervus communicans tibialis* is its cutaneous branch. It arises about the middle of the space, and proceeds downwards in the furrow between the two heads of the gastrocnemius. It will afterwards be seen to unite with the nervus communicans fibularis, a little below the middle of the calf, to form the external saphenous nerve.

The *muscular branches* supply both heads of the gastrocnemius, the plantaris, the soleus, and the popliteus: they come off in the lower part of the space. The branch to the popliteus requires special notice. It arises lower down than the others, and crosses the superficial surface of the popliteal artery to reach the outer side of that vessel. It then runs downwards on the posterior surface of the popliteus muscle, and gains its deep or anterior surface by winding round its lower border. This will be better seen when the muscle itself is dissected.

The *articular branches* are three in number, and great care is required for their dissection. They are given off by the internal popliteal nerve in the upper part of the space, and they accompany the azygos and the two internal articular arteries. That which accompanies the internal inferior articular artery is larger than the other two, and can be easily discovered as it runs along the upper border of the popliteus muscle.

The External Popliteal Nerve is the smaller of the two terminal branches of the great sciatic, and it ends on the

outer side of the neck of the fibula by dividing into the anterior tibial and the musculo-cutaneous. It does not traverse the entire length of the popliteal space. It runs downwards and outwards along the inner side of the biceps, and leaves the space by following closely the tendon of this muscle. It now lies in the interval between the outer head of the gastrocnemius and the biceps, and finally turning forwards round the neck of the fibula, it ends under cover of the upper part of the peroneus longus. In this part of its course it gives off cutaneous and articular branches.

The *cutaneous branches* are two in number, viz. the nervus communicans fibularis, and one to the skin on the anterior and outer aspect of the leg in its upper part. They frequently arise by a common trunk. The *nervus communicans fibularis* arises from the external popliteal in the popliteal space, and is continued downwards over the outer head of the gastrocnemius. It ultimately unites with the nervus communicans tibialis, to form the external saphenous nerve.

The *articular branches* are three in number. They accompany the external articular branches of the popliteal artery, and the anterior recurrent tibial branch of the anterior tibial artery. They are of small size, and difficult to dissect. The *recurrent articular nerve* springs from the termination of the external popliteal nerve, and will be dissected at a later stage.

Popliteal Artery.—The popliteal artery is the terminal part of the great arterial trunk of the lower limb. It begins at the opening in the adductor magnus, where it is continuous with the femoral artery, and it ends at the lower border of the popliteus muscle by dividing into the anterior and posterior tibial arteries. This division is at present hidden from view by the upper border of the soleus muscle, but it will be exposed in the dissection of the leg.

The course which the popliteal artery takes through the popliteal space is not straight. In the first instance it inclines obliquely downwards and outwards, so as to gain the middle of the space in the interval between the two condyles of the femur. From this point to its termination it takes a vertical course downwards. Throughout the greater part of its length it is placed deeply. In the upper part of the space it is covered by the semimembranosus, but when it gains the interval between the two condyles it is simply covered by the integuments and fasciæ. This superficial part of the vessel is very short, however—not more than about an inch—because it at once passes onwards between the two heads of the gastrocnemius, is crossed by the plantaris, and finally at its termination sinks under cover of the upper border of the soleus. Throughout its whole course the popliteal artery rests upon the floor of the popliteal space. In its upper part it is separated from the femur by some fatty tissue; then it crosses the posterior ligament of the knee-joint, and lastly it comes into contact with the fascia covering the popliteus muscle.

The *popliteal vein* is placed upon a more superficial plane, and crosses the artery. In the upper part of the space it is placed upon the outer side of the artery, whereas in the lower part it is situated upon its inner side. The two vessels, however, are in close association throughout. The *internal popliteal* nerve is superficial to both vessels, and crosses the artery from without inwards; in the upper part of the space it lies on the outer side of the artery, but in the lower part it lies on the inner side.

The branches of the popliteal artery are:—

1. Muscular.
2. Cutaneous.
3. Articular.

Muscular Branches are present in an upper and a lower set. The *upper branches* are distributed to the hamstring

muscles near their insertions. The *lower branches*, termed the *sural arteries*, end chiefly in the two heads of the gastrocnemius; but small twigs also go to the soleus and plantaris.

The *cutaneous branch*, called the *superficial sural*, usually arises from one of the sural muscular branches, and supplies the integument over the upper part of the calf of the leg. It lies in the groove between the two heads of the gastrocnemius with the nervus communicans tibialis.

The Articular Arteries are five in number, viz. two superior, two inferior, and one median or azygos.

The Superior Articular Arteries spring from the main trunk as it passes between the condyles of the femur. One proceeds from each side of the popliteal, and they are called *internal* and *external*, according to the direction which they take. They will be found resting directly upon the back of the femur, and will be observed to incline slightly upwards, and then to wind round the bone immediately above the condyles. The external artery is the larger of the two. The student is apt to mistake a muscular branch for one or other of these vessels; but their close apposition to the femur should in all cases be sufficient to distinguish them.

The superior external articular artery runs outwards under cover of the biceps, and disappears from the popliteal space by piercing the external intermuscular septum and entering the substance of the vastus externus muscle. The *superior internal articular* proceeds inwards under cover of the semimembranosus, and leaves the popliteal space by passing forwards beneath the tendon of the adductor magnus to reach the vastus internus muscle.

The Inferior Articular Arteries arise from the popliteal as it lies on the lower part of the posterior ligament of the knee-joint. The *inferior external articular artery* takes a transverse course outwards, under cover of the plantaris and outer head of the gastrocnemius, to gain a point on

the outer side of the knee, immediately above the head of the fibula. It proceeds onwards under cover of the external lateral ligament of the knee-joint. The *inferior internal articular artery* takes a very oblique course downwards and inwards, under cover of the inner head of the gastrocnemius, and along the upper border of the popliteus muscle, to gain the inner side of the tibia below the internal tuberosity. Here it turns forwards under cover of the internal lateral ligament of the knee-joint.

The Azygos Articular Artery springs from the popliteal as it lies upon the posterior ligament of the knee-joint. It pierces this ligament to reach the synovial membrane.

Obturator Nerve.—This minute nerve will be found lying upon the popliteal artery. Trace it upwards, and it will be seen to enter the space by piercing the lower fibres of the adductor magnus; follow it downwards, and perhaps you may be able to see it entering the knee-joint by penetrating the posterior ligament.

BACK OF THE THIGH.

The dissection of the back of the thigh must be completed on the fourth day. The structures met with after the skin has been thrown back are:—

1. Superficial fascia.
2. Cutaneous nerves.
3. Deep fascia.
4. Muscles, { Biceps. Semitendinosus. Semimembranosus. Quadratus femoris. Adductor magnus.
5. Nerves, { Small sciatic. Great sciatic.
6. Arteries, { Branches of the external and internal circumflex. Four perforating arteries.

Reflection of Skin.—A vertical incision must be made in the middle line of the thigh through the belt of skin

which still encircles the limb posteriorly. The two flaps can then be reflected, the one outwards and the other inwards.

Superficial Fascia—Cutaneous Nerves.—In the fatty superficial fascia thus brought into view cutaneous twigs from three sources must be looked for—(1) Along the *middle line* of the limb a few minute branches of the *small sciatic* may be discovered; (2) Towards *the outer side* of the thigh some twigs from the *external cutaneous* nerve may be detected; (3) Lastly, towards *the inner aspect* of the limb endeavour to find some offsets from the *internal cutaneous* and *obturator* nerves.

Deep Fascia.—On removing the superficial fascia the deep fascia will be observed to be exceedingly thin. It must now be turned aside, and in doing this be careful of the trunk of the small sciatic nerve, which passes down in the middle line of the limb immediately subjacent to the fascia.

Hamstring Muscles.—The biceps is recognized from its diverging outwards to form the outer and upper boundary of the popliteal space. The semitendinosus and semimembranosus extend downwards on the inner side of the posterior aspect of the thigh, the former on the superficial aspect of the latter. In cleaning these muscles the dissector should proceed cautiously to work, otherwise he is certain to injure the arterial and nervous twigs which enter them. The latter may be easily secured by pulling upwards the upper part of the great sciatic nerve, and at the same time gently separating the muscles with the fingers.

The Common Origin of the Biceps and Semitendinosus is attached to the posterior part of the ischial tuberosity, internal to the attachment of the semimembranosus. Its external portion is tendinous, but internally it is fleshy. The tendinous portion consists of a broad anterior and a

narrower posterior lamina, into which some fibres of the great sacro-sciatic ligament are continued. The outer borders of these two laminæ unite so as to form a single flattened tendon, which is thus folded on itself with the concavity directed inwards. All the muscular fibres which spring from the concavity of the common tendon, and those which arise directly from the bone, belong to the semitendinosus. The biceps arises from the hinder surface of the posterior lamina, and from a continuation of the latter, which is prolonged on the anterior surface and inner border of the muscle as far as the middle of the thigh.

The Biceps Flexor Cruris arises by two heads—a *long*, or *ischial*, and a *short*, or *femoral*—and is inserted chiefly into the fibula. The *long head* arises from the ischium by the common tendon, as above described. The muscular fibres pass downwards, with an inclination outwards, and end in a tendon which at first appears as an aponeurotic expansion on the external and anterior surface of the muscle, and gradually becomes round and thick, and ultimately free from muscular fibres at the lower border of the external condyle of the femur. The *short head* arises from the outer lip of the linea aspera, from the upper half of the external supracondyloid ridge, and from the external intermuscular septum; its parallel fibres run obliquely downwards and outwards, and join the anterior and inner surface of the tendon of insertion. This tendon passes downwards, concealing the external lateral ligament, and at the head of the fibula splits into two parts, which enclose the fibular attachment of the ligament, and are separated from it by a synovial bursa. The posterior part of the tendon is inserted into the outer side of the head of the fibula, immediately in front of the styloid process, and gives off an aponeurotic slip to the fascia of the leg. The anterior part of the tendon is attached to the bone in front of the ligament, and gives off a slip (in some cases

strong, but generally feeble) to the adjacent part of the outer tuberosity of the tibia.

The Semitendinosus arises from the tuberosity of the ischium by the common tendon, and also by fleshy fibres directly from the bone. Its muscular belly is flattened above, but rounded below, and ends in the lower third of the thigh, where its long cylindrical tendon becomes free from muscular fibres. A narrow tendinous intersection appears on the posterior surface of the muscle about the middle of the thigh, and is directed obliquely downwards and outwards. The tendon of insertion appears on the inner border of the muscle nearly opposite the tendinous intersection, and becomes free from muscular fibres about two inches above the internal condyle. It passes downwards on the semimembranosus muscle, then bends forwards, crosses the internal lateral ligament of the knee-joint, and, becoming flattened, is inserted into the upper part of the internal surface of the shaft of the tibia, near the anterior border of that bone, and immediately below the tendon of the gracilis. From its lower border aponeurotic fibres pass into the deep fascia of the leg; its upper border is adherent to the gracilis for about half an inch from its insertion, and both tendons are concealed by the expanded insertion of the sartorius. A synovial bursa lies between the three tendons and the internal lateral ligament.

The Semimembranosus arises from the tuberosity of the ischium, behind the quadratus femoris. The tendon of origin is broad at its attachment to the bone, and narrows as it passes inwards beneath the origin of the biceps; it then expands again, assuming a remarkable shape, something like the blade of a razor, the outer border being thick and rounded, the inner thin and membranous. This tendon passes downwards and inwards under cover of the semitendinosus, and is folded in such a manner as to form a groove, in which the latter

muscle lies. The thick outer border of the tendon continues free from fleshy fibres as far as the middle of the thigh. The greater number of muscular fibres arise from the anterior surface of the tendon, a thin layer only arising from the posterior surface. The tendon of insertion is situated on the anterior surface and inner border of the muscle, and becomes free behind the inner condyle of the femur. The muscular fibres pass obliquely downwards and inwards from the tendon of origin to the tendon of insertion. The main mass of the tendon of the semimembranosus is inserted into the groove on the back of the internal tuberosity of the tibia, under cover of the internal lateral ligament of the knee-joint. Three additional attachments, however, require to be noted. These are effected by aponeurotic extensions from the tendon which go—(1) to the back of the knee-joint, where it forms a considerable part of the posterior ligament; (2) to the surface of the popliteus muscle, which is covered by the expansion; and (3) to the internal lateral ligament of the knee-joint.

The Great Sciatic Nerve commences at the lower border of the great sacro-sciatic foramen, and terminates a little below the middle of the thigh by dividing into the internal and external popliteal nerves. Its relations in the gluteal region have already been studied. In the thigh it lies on the posterior surface of the adductor magnus muscle, and is covered by the long head of the biceps. It gives branches to both heads of the biceps, to the semitendinosus, to the semimembranosus, and to the adductor magnus; the branches to the two latter muscles arise in common. In a few cases it may be observed to give off a long articular twig, which enters the popliteal space and takes the place of the superior external articular nerve which, as a rule, comes from the external popliteal nerve.

The Quadratus Femoris Muscle should next be examined. It arises from the outer border of the tuberosity of the

ischium, immediately in front of the origin of the semi-membranosus, and is inserted into the linea quadrati of the femur. Its fibres are parallel and fleshy, and form a flat oblong muscle.

The quadratus femoris may now be reflected by cutting through its insertion. The posterior part of the capsule of the hip-joint, together with the insertion of the obturator externus muscle, and the termination of the internal circumflex artery will be exposed.

The Termination of the Internal Circumflex Artery is seen close to the upper border of the adductor magnus, where it divides into a transverse and an ascending branch. The *transverse branch* passes backwards between the quadratus femoris and adductor magnus, supplies branches to the upper parts of the hamstring muscles, and anastomoses with the sciatic, external circumflex, and first perforating arteries. The *ascending branch* passes obliquely upwards and outwards under cover of the quadratus femoris, and upon the obturator externus. Its terminal twigs ramify in the neighbourhood of the digital fossa.

The External Circumflex Artery also sends a branch to the back of the thigh. In a well-injected subject the terminal twig of its middle division will be noticed appearing from amidst the fibres of the vastus externus at its upper part. It may be seen to anastomose with the first perforating and the internal circumflex arteries.

The Capsular Ligament will be seen to be only loosely attached to the posterior aspect of the neck of the femur, but very firmly to the acetabular brim.

Perforating Arteries.—Four perforating arteries will be found emerging from the surface of the adductor magnus muscle close to the linea aspera of the femur. They are called *first*, *second*, *third*, and *fourth*, according to the level at which they appear from above downwards. The *fourth*

is the terminal branch of the profunda artery of the thigh, and it makes its appearance about an inch above the opening in the muscle through which the popliteal artery enters the popliteal space. The perforating arteries and their branches must be thoroughly cleaned, together with the apertures in the adductor magnus through which they pass. It will then be seen that they do not pierce the fleshy substance of the muscle. Prepared for each is a tendinous archway, and they reach the back of the thigh by passing between these and the linea aspera, to which the piers of the various arches are attached.

These openings lie in the same line, and are in all respects analogous to the large opening in the adductor magnus muscle for the popliteal artery. The result obtained is the same in each case. When the muscle contracts, the vessels are protected from pressure.

Adductor Magnus.—To bring this muscle more fully into view, and at the same time to facilitate the process of cleaning its radiating fibres, it is well to reflect the hamstring muscles from their origins. First divide the conjoined tendon of the biceps and semitendinosus. This displays the precise origin of the semimembranosus, and when the dissector has again examined this under the present more advantageous circumstances he should divide it also.

Anastomosis on the Posterior Aspect of the Limb.—In a well-injected subject a chain of anastomoses, in which every link is complete, can be traced from the gluteal region down the back of the thigh to the popliteal space. The present is the best time to study this. Commencing above, we find the gluteal artery anastomosing with the sciatic, and the sciatic with the internal circumflex. In the back of the thigh this chain is carried downwards by the internal and external circumflex arteries anastomosing with the first perforating, each perforating artery inosculating with the one below it, and lastly, the lower

perforating arteries effecting junctions with the muscular branches which the popliteal artery gives to the hamstrings.

FRONT OF THE THIGH.

The body is now turned round so as to lie on its back. The pelvis is supported by two blocks, and the lower limbs are stretched out at full length upon the table (Fig. 3, p. 19).

Surface Anatomy.—The anterior superior spine of the ilium should in the first place be recognized, and the crest of the ilium traced as it proceeds outwards and backwards from this. The boundary line between the front of the thigh and the region of the abdomen is formed by Poupart's ligament, which stretches from the anterior superior spine of the ilium to the spine of the pubis. Its course and position are marked on the surface by a faint groove. By running the finger along this when the thigh is fully extended the ligament may be felt. At its inner end the spine of the pubis should be determined, and then the finger may be carried inwards on the crest of the pubis to the symphysis pubis. The rami of the pubis and ischium, leading downwards and backwards to the tuberosity of the ischium, constitute the upper boundary of the thigh on its internal aspect, and their relation to the surface must therefore be ascertained. Below Poupart's ligament in the extended position of the thigh, there is a faint depression corresponding in position to Scarpa's triangle.

In the dissection of the front of the thigh, the skin is also reflected from the anterior aspect of the knee. The dissector should therefore take the present opportunity of studying the surface anatomy of this articulation. The patella forms a marked prominence in front of the joint. When the limb is extended and the extensor muscles on the front of the thigh are relaxed, the patella will be found

to be freely movable when grasped firmly between the finger and thumb. Note its change of position when the leg is flexed on the thigh at the knee-joint. It passes downwards, and lies in front of the interval between the femur and tibia. The patellar surface of the femur can now be felt. The powerful ligamentum patellæ passes vertically downwards from the patella to the anterior tuberosity of the tibia and is easily distinguished. The massive condyles of the femur should next be studied and compared. The internal condyle is much the more prominent of the two, and immediately above its tuberosity the adductor tubercle can be recognized. The articular interval between the condyles of the femur and the head of the tibia is not visible on the surface, but it can readily be felt by the finger. The three tuberosities of the tibia should lastly be studied, and the position of the head of the fibula on the posterior and lower aspect of the external tuberosity ascertained.

SUPERFICIAL DISSECTION.

This dissection comprises the examination of the following parts :—

1. Superficial fascia.
2. Internal saphenous vein, and its several tributaries.
3. Arteries, { Superficial pudic. Superficial epigastric. Superficial circumflex iliac.
4. Lymphatic glands and vessels.
5. The saphenous opening.
6. Cutaneous nerves.
7. The fascia lata.
8. The bursa patellæ.

Reflection of Skin.—*Incisions.*—(1) From the anterior superior spine of the ilium along the line of Poupart's ligament to the symphysis pubis; (2) from the inner extremity of this line downwards, round the scrotum, and

along the inner aspect of the thigh for four inches; (3) from the lower extremity of this vertical incision transversely outwards, across the front of the thigh, to the outer aspect of the limb (Fig. 3, p. 9).

The quadrilateral flap of skin thus traced out must be raised carefully from the subjacent superficial fascia and turned outwards.

Superficial Fascia.—The fatty superficial fascia which is now exposed is continuous with the corresponding layer on the front of the abdomen, and it is regarded by some anatomists as being composed of two layers. This subdivision we consider needless and artificial. In the lower part of the abdominal wall above Poupart's ligament it is true the superficial fascia presents two distinct strata—one a fatty layer continuous over Poupart's ligament, with the superficial fascia on the front of the thigh, and sometimes termed *the fascia of Camper;* the other, a deeper layer, firm and membranous and devoid of fat, called *the fascia of Scarpa.* As this latter fascial stratum is attached to the fascia lata (deep fascia of the thigh), immediately below Poupart's ligament, it is necessary that it should receive some attention.

To demonstrate the fascia of Scarpa the dissectors of the lower limb and abdomen should work in conjunction with each other. A transverse incision should be made through the entire thickness of the superficial fascia on the front of the abdomen, from the anterior superior spine of the ilium to the middle line of the body. On raising the lower edge of the divided fascia the two layers can be easily distinguished. Insinuate the fingers between the fascia of Scarpa and the pearly-looking tendon of the external oblique. Little resistance will be encountered, as it is only bound down by some lax areolar tissue. The fingers can be readily carried downwards behind the fascia of Scarpa as far as Poupart's ligament. Here it will be found that they can force their way no farther. The

passage of the hand into the thigh is barred by the blending of the fascia of Scarpa with the fascia lata. At this level it ceases to exist; it loses its identity through its fusion with the deep fascia. The fatty superficial layer of Camper, however, as we have said, is continued onwards as the superficial fascia of the thigh.

But it is necessary to study more closely the line along which the fascia of Scarpa unites with the fascia lata. Its direction does not correspond with that of Poupart's ligament: it is more nearly horizontal. Internally the union takes place along the line of Poupart's ligament; but as it is traced outwards, it will be seen to fall somewhat below the ligament. When urine is effused under the superficial fascia of the anterior abdominal wall, this attachment of the fascia of Scarpa prevents its passage downwards in front of the thigh.

Dissection.—In the superficial fascia blood-vessels, glands, lymphatic vessels, and nerves are embedded, and these must now be dissected out. First look for the large internal saphenous vein. It will be found extending up the thigh a little way internal to the middle line of the limb. Trace it upwards till it reaches a point about two inches from Poupart's ligament. At this point it dips through the deep fascia, and joins the femoral vein. It is not desirable to define the opening in the fascia lata through which it passes until a later stage of the dissection. Several tributaries join the internal saphenous vein at this point, and these should be dissected along with the small superficial arteries of the groin which accompany them.

The large lymphatic glands of the groin must also be dissected out from the fatty tissue in which they lie. In doing this care must be taken to preserve as many of the minute thread-like lymphatic vessels which enter and leave the glands as possible. A small artery and vein should also be traced to each gland.

Superficial Inguinal Vessels.—Three minute arteries termed the superficial epigastric, the superficial external pudic, and the superficial circumflex iliac pierce the deep fascia below Poupart's ligament, and radiate from each other for the supply of the glands and integument of the groin. They all spring from the femoral artery immediately after it enters the thigh.

The *superficial external pudic* comes forwards through the cribriform fascia (a thin fascial layer, which is spread over the saphenous opening), and runs inwards and upwards across the spermatic cord. It supplies the skin of the scrotum and penis.

The *superficial epigastric* turns upwards and leaves the thigh by crossing Poupart's ligament about its middle. It is distributed chiefly to the skin on the front of the abdomen.

The *superficial circumflex iliac* frequently arises in common with the superficial epigastric. It is very minute, and courses upwards and outwards along Poupart's ligament to the anterior superior spine of the ilium.

The *veins* which accompany these arteries converge towards the saphenous opening and join the internal saphenous vein near its termination.

Lymphatic Glands and Vessels.—The disposition of the lymphatic glands into two groups will now be evident—an upper *inguinal* group along the line of Poupart's ligament, and a lower *femoral* group, which extends for a short way down the thigh along the line of the internal saphenous vein.

In a spare subject, or better still in a dropsical subject, the general arrangement of the lymphatic vessels may also be made out. To the femoral group of glands proceed the vessels of the lower limb; to the inguinal glands go the lymphatic vessels from the genitals, perineum, and the surface of the abdomen. These are termed the *afferent*

vessels. In addition to these, numerous vessels pass between the various glands and connect them with each other. The lymphatic vessels which lead the lymph away from the glands are called the *efferent vessels*. A large number of these pass through the saphenous opening, others pierce the deep fascia. They join the glands which lie in relation to the femoral and external iliac arteries.

Saphenous Opening.—This is the opening in the deep fascia through which the saphenous vein passes to effect its junction with the femoral vein. It requires an experienced dissector to display it in a satisfactory manner. Begin by removing the lymphatic glands. In doing this bear in mind that the *crural branch* of the genito-crural nerve pierces the fascia lata in the middle line of the thigh about an inch or so below Poupart's ligament. Take care also of the two divisions of the *middle cutaneous nerve*, which make their appearance in the same line about three inches below Poupart's ligament. A thin fascia, called the *cribriform fascia*, is spread over the opening and hides it from view. This fascia has received the name of 'cribriform,' because it is pierced by the saphenous vein and by numerous lymphatic vessels. Some difference of opinion exists as to what this fascia really is. It is regarded by many as being a part of the superficial fascia, but it is more correct to look upon it as being a thin layer of fascia lata carried over the opening, or in other words, a prolongation inwards of the outer margin of the opening.

To define the saphenous opening the dissector should commence by cautiously removing the superficial fascia from the fascia lata over the upper parts of the adductor longus and pectineus muscles. The deep fascia at this point is called the *pubic portion* of the fascia lata, and as it is cleaned, from within outwards, it will be observed to recede gradually from the surface and to be continued behind the femoral vessels. The clearly-defined inferior cornu of the saphenous opening will now be brought into

view, curving under the internal saphenous vein, and blending with the *pubic portion of the fascia lata.* The *cribriform fascia* must be removed so as to display the outer boundary of the opening. In doing this take great care of the subjacent sheath of the femoral vessels to which it is more or less firmly attached. To a certain extent this dissection is artificial, seeing that the cribriform fascia is merely a continuation inwards of the outer lip of the opening. The outer boundary is usually very much broken up by the superficial branches of the femoral artery which pierce it, and its definition is a matter of some difficulty. In a spare subject, however, the line of demarcation between the *cribriform fascia* and the *iliac portion of the fascia lata** may be distinguished.

The importance of the saphenous opening consists in the fact that it is through it that a femoral hernia makes its way to the surface. Its oval shape is now apparent: it is very narrow, being not more than half an inch in width ; but it is at least one and a-half inches long. Its inner boundary lies on a deeper plane than the outer boundary; it is formed by the receding *pubic portion* of the fascia lata. The outer boundary is crescentic, and is known as the *falciform edge* of the opening. It is formed by the *iliac portion* of the fascia lata. The *inferior cornu* of the falciform edge curves inwards under the saphenous vein, in the form of a very distinct process which joins the pubic part of the fascia lata. The *superior cornu*, not so well defined, sweeps inwards in front of the upper part of the subjacent femoral sheath, and joins the front of Gimbernat's ligament.

Reflection of Skin.—The next step in the dissection consists in reflecting the skin from the lower two-thirds of the front of the thigh, and also from the anterior aspect

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* This is the name which is given to that part of the fascia lata which lies external to the opening.

of the knee. This is effected by extending the vertical incision, which has already been made upon the inner aspect of the thigh downwards to the internal tuberosity of the tibia, and then carrying a transverse incision from the lower end of the vertical cut outwards over the front of the leg to its outer aspect. In raising the skin from the front of the knee take care not to injure the patellar plexus of nerves and the patellar bursa. In reflecting the integument from this extensive area, we have two objects in view: firstly, the dissection of the cutaneous nerves and vessels of the thigh, and secondly, the examination of the entire extent of the fascia lata.

Internal Saphenous Vein.—The internal saphenous vein should be dissected in the superficial fascia to the lower limit of the area from which the skin has been reflected. It is the largest superficial vein of the lower limb. Taking origin on the dorsum of the foot, it extends upwards on the leg. On the inner side of the knee it will be seen to be placed very far back. As it reaches the thigh it inclines somewhat forwards, and runs upwards on the front and inner aspect of the limb to the saphenous opening in the fascia lata. Through this aperture it passes to join the femoral vein.

In its course along the thigh it receives several tributaries. Two of these are of large size, viz. an *anterior branch*, which collects the blood from the front and outer aspects of the limb, and a *posterior branch*, which performs a similar office for the posterior and inner aspects of the thigh. They both enter the internal saphenous vein near its termination. In addition to these, the *three small veins* corresponding to the superficial inguinal arteries converge towards the saphenous opening, and join the saphenous trunk as it disappears through it.

Cutaneous Nerves.—The cutaneous nerves are now to be looked for in the superficial fascia. The main stems are six in number, and are derived from two sources.

Three come directly from the *lumbar plexus,* and *three* are branches of the *anterior crural:*—

From lumbar plexus,	Ilio-inguinal. Crural branch of genito-crural. External cutaneous.
From anterior crural,	Middle cutaneous. Internal cutaneous. Long saphenous.

The *ilio-inguinal nerve* will be found as it escapes from the external abdominal ring in company with the spermatic cord. Its branches go for the most part to the scrotum, but some are distributed to the skin on the upper and inner side of the thigh.

The *crural branch* of the genito-crural nerve pierces the fascia a little way below Poupart's ligament, and to the outer side of the femoral artery. With a little care a communication between this nerve and the middle cutaneous may be made out. It supplies a limited area of skin on the upper part of the front of the thigh.

The *external cutaneous* is distributed on the outer aspect of the thigh. It pierces the deep fascia in two parts. Of these, one—the *posterior* division—appears about two inches below the anterior superior iliac spine, and proceeds backwards and downwards. Some twigs of this nerve may be followed to the lower part of the gluteal region. The *anterior* division comes to the surface about two inches lower down. It is the larger of the two, and has a wide area of distribution. It extends as low as the knee-joint. Previous to its division the external cutaneous nerve lies in a prominent ridge of the fascia lata, which descends vertically from the anterior superior spine of the ilium. This may be split up to expose it.

The *middle cutaneous nerve* pierces the fascia lata in the middle line of the thigh about three or four inches below Poupart's ligament. It usually appears as two nerves which perforate the fascia at two points a short distance

apart from each other. Both branches extend downwards as low as the knee, which they reach on its inner aspect.

The *internal cutaneous nerve*, following the example of the external cutaneous and the middle cutaneous, divides

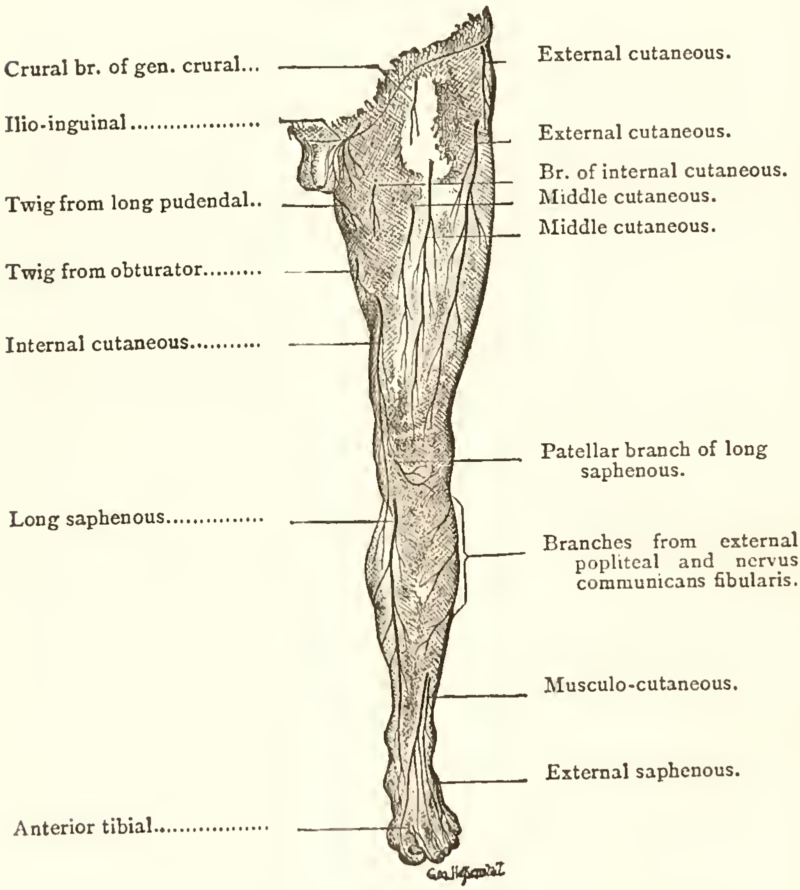

FIG. 60.

Diagram of Cutaneous Nerves on the anterior aspect of the Lower Limb.

into two portions—an anterior and a posterior—which perforate the deep fascia on the inner aspect of the limb, and at some distance apart from each other. The *anterior division* makes its appearance through the fascia lata in the

lower third of the thigh, a short distance in front of the internal saphenous vein. It descends towards the knee, and its terminal branches turn forwards and outwards in front of the patella. The *posterior division* reaches the surface on the inner side of the knee, behind the long saphenous nerve, and proceeds downwards to supply the integument on the inner side of the upper part of the leg. But the main stem of the internal cutaneous nerve, before it divides, likewise sends a few twigs through the fascia lata to reach the skin on the upper and inner aspect of the thigh. These make their appearance along the line of the internal saphenous vein.

The *long saphenous nerve* becomes cutaneous on the inner side of the knee by perforating the fascia between the tendons of the sartorius and gracilis muscles. The guide to it is the superficial branch of the *anastomotic artery* which descends alongside of it. It follows the course of the internal saphenous vein into the leg. Before it pierces the fascia it gives off a *patellar* branch.

The *patellar branch* of the long saphenous nerve pierces the sartorius muscle and the fascia lata on the inner side of the knee, and turns outwards and forwards in front of the joint below the level of the patella.

Four of the cutaneous nerves of the thigh have been noticed to send twigs to the skin over the knee-joint, viz. the anterior division of the external cutaneous, the middle cutaneous, the anterior division of the internal cutaneous, and the long saphenous. These nerves communicate with each other and form an interlacement which is situated over the patella, the ligamentum patellæ, and upper part of the tibia. It is termed the *patellar plexus*.

On the inner side of the thigh two minute cutaneous nerve-twigs sometimes make their appearance which do not belong to any of the above main cutaneous trunks. One appears below the ilio-inguinal nerve, and is a twig from the long pudendal branch of the small sciatic; the other pierces the deep fascia half-way down the inner side of the thigh, and comes from the obturator nerve.

Fascia Lata.—This is the name which is given to that portion of the general aponeurotic investment of the lower limb which clothes and preserves the figure of the thigh. It should be carefully cleaned by removing the remains of the superficial fascia. This being done, the dissector will be struck with the marked difference in strength which it shows on the outer and inner aspects of the thigh. Externally it is so dense and strong that it appears to be more tendinous than aponeurotic in its character. The reason of this is, that the tensor fasciæ femoris muscle and the greater portion of the gluteus maximus are inserted into it upon this side of the limb. The strong band thus formed goes under the name of the *ilio-tibial band*, from its being attached above to the crest of the ilium, and below to the outer tuberosity of the tibia and to the head of the fibula. It acts as a powerful brace on the outer aspect of the limb, which in the erect posture helps to steady the pelvis, and at the same time keep the knee-joint firmly extended. Internally, the fascia lata is so exceedingly delicate and thin that the subjacent muscular fibres shine through it, and it is very apt to be removed with the superficial fascia unless care be exercised in the dissection.

Superiorly, around the root of the limb, the fascia lata is attached to Poupart's ligament and the bones of the pelvis. *Behind*, it is continuous with the gluteal aponeurosis, and through this it is fixed to the coccyx, sacrum, and crest of the ilium. On the *outer side*, it is attached to the crest of the ilium ; and on the *inner side*, to the body of the pubis, the side of the pubic arch, and to the tuberosity of the ischium. *In front*, its upper attachment is complicated by the presence of the saphenous opening. This aperture separates the fascia lata into an outer or iliac portion and an inner or pubic portion. This subdivision only extends downwards to the lower border of the saphenous opening. The *iliac portion* is attached along the whole length of Poupart's ligament. Its inner crescentic margin bounds the saphenous opening

externally and forms its falciform edge. The superior cornu of this edge blends with Gimbernat's ligament, whilst its inferior cornu joins the pubic portion of the fascia lata. The *pubic portion* clothes the upper portions of the adductor longus and pectineus muscles. It recedes from the surface as it is traced outwards and passes behind the femoral vessels. In this situation it forms the posterior wall of the femoral sheath and is continuous above with the *fascia iliaca** which covers the ilio-psoas muscle in the iliac fossa. To the inner side of the femoral vessels the pubic portion of the fascia lata is attached above to the ilio-pectineal line of the pubic bone. The *cribriform fascia*, as previously stated, is to be regarded as a thin piece of the fascia lata, stretched across the saphenous opening. Externally, it is continuous with the falciform edge of the iliac portion of the fascia; internally, it blends with the front of the pubic portion.

In the neighbourhood of the knee the fascia lata is continuous behind with the popliteal fascia, whilst on the lateral and front aspects of the joint it is attached to the various bony prominences and to the different tendons in this locality. Here it helps to strengthen and support the capsular ligament of the knee-joint.

Intermuscular Septa.—But the fascia lata has other offices to perform besides that of forming a continuous investment for the thigh. From every part of its deep surface processes pass off which penetrate the limb and constitute sheaths for the muscles and other structures which compose it. Three of these are especially strong, and form distinct septa or partitions which reach the femur and are attached to the linea aspera on its posterior aspect. These partitions are termed the intermuscular septa, and are so disposed

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* The dissector must keep clearly before him the distinction between the *fascia iliaca* and the *iliac portion of the fascia lata*. The former is a part of the general aponeurotic lining of the abdominal cavity; the latter is a part of the aponeurotic investment of the thigh.

that they intervene between the three great groups of muscles in this region. The *external intermuscular septum* is placed between the extensor muscles in the front of the thigh and the hamstring muscles on the posterior aspect of the thigh ; the *internal intermuscular septum* intervenes between the extensor muscles and the adductor muscles on the inner aspect of the limb ; whilst the *posterior intermuscular septum*, very weak and inconspicuous in comparison with the other two, is interposed between the adductor

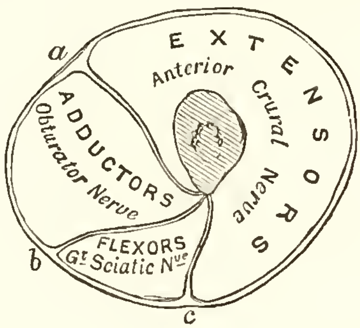

FIG. 61.

Diagram to show the arrangement of the three Intermuscular Septa and the three Osteo-fascial Compartments of the Thigh (after Sir William Turner).

a. Internal intermuscular septum. | *b*. Posterior intermuscular septum.
c. External intermuscular septum.

and the hamstring muscles. These partitions will be disclosed in the subsequent dissection. In the meantime merely observe that the internal and the external septa show on the surface of the fascia in the lower part of the thigh as white lines. The thigh is in this manner divided into three osteo-fascial compartments, viz. *an anterior* containing the extensor muscles and anterior crural nerve ; *a posterior* holding the hamstrings and the great sciatic nerve ; and *an internal* for the adductors with the obturator nerve. (Fig. 61.)

Patellar Bursa.—This is situated upon the superficial aspect of the patella. Pinch up the fascia lata as it passes over this bone with the forceps, and make a transverse incision through the wall of the sac large enough to admit

the finger. It will then be seen to extend downwards for a short distance upon the ligamentum patellæ. It is usually intersected by fibrous bands and cords.

DEEP DISSECTION.

In this dissection, the following parts require to be examined :—

1. The femoral sheath.
2. Crural branch of genito-crural nerve.
3. External cutaneous nerve.
4. Sartorius muscle.
5. Anterior crural nerve and its branches.
6. Femoral vessels and their branches.
7. Psoas and iliacus internus muscles.
8. Quadriceps extensor, { Rectus femoris. Vastus internus. Crureus and subcrureus. Vastus externus. }
9. Tensor fasciæ femoris muscle.
10. Deep layer of the ilio-tibial band of fascia lata.
11. The external and internal intermuscular septa.

Poupart's Ligament; Gimbernat's Ligament.—Although, properly speaking, both of these ligaments belong more to the abdominal wall than the thigh, it is very essential that the dissector should obtain some knowledge of their connections before he proceeds further with the dissection. *Poupart's ligament* is merely the thickened lower border of the aponeurosis of the external oblique muscle of the abdominal wall folded backwards upon itself. It thus presents a rounded surface towards the thigh, and a grooved surface towards the abdomen. By its outer extremity it is fixed to the anterior superior spine of the ilium. Internally, it has a double attachment, viz.—(1) to the spine of the pubis; (2) through the medium of Gimbernat's ligament to the inner part of the ilio-pectineal line. Poupart's ligament pursues an oblique course between its iliac and pubic attachments, and at the

same time describes a gentle curve, the convexity of which is turned downwards. By its lower border it affords attachment to the fascia lata, and when this is divided it at once loses its curved direction.

Gimbernat's ligament is a small triangular piece of aponeurotic fascia which occupies the interval between the inner part of Poupart's ligament and the inner inch of the ilio-pectineal line—being attached by its margins to both. Its base is sharp, crescentic, and free, and abuts against the femoral sheath. Gimbernat's ligament occupies a very oblique plane: its femoral surface looks downwards, whilst its abdominal surface is directed upwards.

Femoral Sheath.—The exposure of the femoral sheath is the next step in the dissection of the thigh. To attain this object the *iliac portion* of the fascia lata must be partially reflected. Divide the superior horn of the outer crescentic margin of the saphenous opening, and then carry the knife outwards along the lower border of Poupart's ligament, so as to sever the attachment of the fascia lata to this thickened band. This incision should extend to within an inch of the anterior superior spine of the ilium. The piece of fascia marked out by the incision above, and by the outer free margin of the saphenous opening internally, must be carefully raised from the subjacent femoral sheath and thrown downwards and outwards. On the removal of a little loose fat, the *femoral sheath* will be brought into view as it enters the thigh under Poupart's ligament. Isolate it carefully from adjacent and surrounding parts, by carrying the handle of the knife gently round it—insinuating it first between the sheath and *Poupart's ligament*, then between the sheath and *Gimbernat's ligament*, which lies internal to it.

The funnel-shaped appearance of the sheath will now be apparent—the wide mouth of the membranous tube being directed upwards into the abdomen, and the narrow inferior

part gradually closing upon the vessels, and fusing with their coats about the level of the lower limit of the saphenous opening. Whilst it presents this appearance, however, it should be noticed that its sides do not slope equally towards each other. The outer side of the sheath indeed is nearly vertical in its direction, whilst the inner wall proceeds very obliquely from above downwards and outwards. If the dissection has been successfully performed, the *crural branch* of the *genito-crural nerve* should be seen piercing the outer wall of the sheath, and the internal saphenous vein, and some lymphatic vessels perforating its anterior and inner walls. Further, if the subject be spare, and the fasciæ well marked, the dissector will in all probability notice that the anterior wall of the sheath in its upper part is strengthened by some transverse fibres which pursue an arched course across it. To these fibres the name of *deep crural arch* is given, in contradistinction to the term *superficial crural arch*, which is frequently applied to Poupart's ligament. In favourable circumstances the deep crural arch may be observed to spring from the under surface of Poupart's ligament about its middle. After traversing the front of the sheath the band expands somewhat, and is attached by its inner extremity to the ilio-pectineal line of the pubic bone behind Gimbernat's ligament.

Constitution of the Femoral Sheath.—The source from which the femoral sheath is derived, and the manner in which it is formed, must next be considered. This entails the study of some of the structures concerned in the construction of the abdominal wall. Unfortunately it is not likely that at this period the dissection of the abdomen is in a sufficiently advanced state for their examination. A small portion of the inner part of the interval between Poupart's ligament and the portion of the innominate bone over which it stretches is filled up by Gimbernat's ligament. Im-

mediately to the inner side of this the femoral vessels, enclosed within the femoral sheath, enter the thigh from the abdominal cavity, whilst to the outer side of these the interval is occupied by the ilio-psoas muscle. Three nerves also find their way into the thigh through this interval, viz. the crural branch of the genito-crural, which passes downwards in the femoral sheath; the anterior crural nerve, which occupies the interval between the psoas and iliacus muscles; and the external cutaneous nerve, which runs behind Poupart's ligament close to its iliac attachment.

The arrangement of the aponeurotic lining of the abdominal cavity with reference to this interval of communication between abdomen and thigh also requires attention. The lower part of the posterior wall of the abdomen, immediately above the thigh, is formed by the iliacus and psoas muscles. These are covered by that part of the aponeurotic lining of the abdomen which receives the name of the *fascia iliaca*. The anterior wall of the abdomen is lined in like manner by a portion of the general lining termed the *fascia transversalis*. To the outer side of the femoral vessels these two fascial layers become continuous with each other, and at the same time are attached to the back of Poupart's ligament. It is behind this that the ilio-psoas, the anterior crural nerve, and the external cutaneous nerve are carried downwards into the thigh. But the external iliac vessels (the femoral vessels in the thigh) with the genito-crural nerve lie in front of the fascia iliaca, or in other words within the fascial lining of the abdomen and, as they proceed downwards behind Poupart's ligament, they carry with them a funnel-shaped prolongation of the lining. This then is the femoral sheath, and the dissector will now readily understand that the *front wall* of the sheath is formed of *fascia transversalis* from the anterior wall of the abdomen above Poupart's ligament, while the *posterior wall* is formed of *fascia iliaca*, prolonged downwards from the posterior abdominal wall. The whole arrangement of the fascia

lining the abdomen has not inaptly been compared to a funnel or filler—the wide expanded part in the abdomen and containing the peritoneum and its contents, the narrow pipe-like part being the femoral sheath which is carried downwards on the vessels behind Poupart's ligament.

Posterior Wall of the Femoral Sheath.—There are still some additional facts relating to the posterior wall of the femoral sheath which require to be mentioned. This is formed, as stated above, by the fascia iliaca; but as this enters the thigh it is seen to be directly continuous with the pubic layer of the fascia lata, and further, it is firmly fixed in position by certain connections which it establishes in the thigh. Thus beyond the femoral sheath it is prolonged in an outward direction over the ilio-psoas muscle, whilst from its posterior aspect a lamina is given off which passes behind that muscle and joins the capsule of the hip-joint.

Interior of the Femoral Sheath.—The femoral sheath should be opened, in order that the arrangement of parts inside may be displayed. Make three vertical and parallel incisions through the anterior wall—one over the femoral artery which occupies the outer part of the sheath, another over the femoral vein, and the third about half an inch internal to the second. The first two should begin at the level of Poupart's ligament, and should extend downwards for an inch and a-half. The most internal of the three incisions should commence at the same point, but should only be carried downwards for half an inch or less. A little dissection will show that the sheath is subdivided by two vertical partitions into three compartments. The femoral artery and crural branch of the genito-crural nerve occupy the *outermost* compartment; the femoral vein fills up the *middle* compartment; whilst in the *innermost* compartment is lodged a little loose areolar tissue, a small lymphatic gland, and

some lymphatic vessels. This last compartment, from its relation to femoral hernia has the special name of *crural canal* applied to it.

Crural Canal.—The boundaries and extent of this canal must be very thoroughly studied. The best way to do this is to introduce the little finger into it and gently push it upwards. Its length is not nearly so great as that of the other two compartments. Indeed it is not more than half an inch long. Inferiorly it is closed, and it rapidly diminishes in width from above downwards. Its superior aperture lies on the outer side of the base of Gimbernat's ligament, and is called the *crural ring*. It is closed by the closely-applied extra-peritoneal fatty tissue. The parts which immediately surround this opening can be readily detected with the finger: externally the *femoral vein*, internally the sharp crescentic base of *Gimbernat's ligament*, anteriorly *Poupart's ligament*, and posteriorly the *pubic bone* covered by the *pectineus muscle*. The portion of the extra-peritoneal fatty tissue which closes the ring is called the *septum crurale*. On the abdominal surface of the septum crurale is the peritoneal lining of the abdominal cavity, and when examined from above both are seen to be slightly depressed into the opening so as to produce the appearance of a dimple.

Femoral Hernia.—Femoral hernia is the name applied to a pathological condition which consists in the protrusion of a viscus or part of a viscus from the abdominal cavity into the region of the thigh. In its descent it passes behind Poupart's ligament along the *crural canal*, or *innermost compartment* of the femoral sheath. The arrangement of parts in connection with the interval between the innominate bone and Poupart's ligament has been carefully considered, and the dissector should therefore be in a position to understand how the occurrence of such a protrusion is rendered possible. To the inner side of the femoral sheath the interval is closed by Gimbernat's ligament, which, by its strength and firm connections, constitutes an impassable barrier in this locality. To the outer side of the femoral sheath a hernial protrusion is equally impossible. Here the fascia transversalis on the anterior wall of the abdomen becomes continuous with the fascia iliaca on the posterior wall of the

abdomen, and along the line of union both are firmly attached to Poupart's ligament.

It is in the region of the femoral sheath then that femoral hernia takes place. Its three compartments open above into the abdominal cavity, but there is an essential difference between them. The two outer, which hold the artery and the vein, are completely filled up by their contents. The crural canal, or innermost compartment, is not; it is much wider than is necessary for the passage of the fine lymphatic vessels which traverse it. Further, its widest part is the upper opening or *crural ring*. It has been noted that this is wide enough to admit the point of the little finger. Here then is a weak point in the parietes of the abdomen, and a source of weakness which is greater in the female than in the male, seeing that in the former the distance between the iliac and pubic spines is proportionally greater, and in consequence the crural ring wider. Femoral hernia, therefore, is more common in the female.

When attempts are made to reduce a femoral hernia, it is absolutely necessary that the course which the protrusion has taken should be kept constantly before the mind of the operator. In the first instance it descends for a short distance in a perpendicular direction. It then turns forward and bulges through the saphenous opening. Should it still continue to enlarge, it bends upwards over Poupart's ligament, and pushes its way outwards towards the anterior superior spine of the ilium. The protrusion is thus bent upon itself: if reduction is to be carried out successfully it must be made to retrace its steps. In other words, it must be drawn downwards, and then pushed gently backwards and upwards. The position of the limb during this procedure must be attended to. When the thigh is fully extended and rotated outwards, all the fascial structures in the neighbourhood of the crural canal are rendered tight and tense. When the limb is flexed at the hip-joint and rotated inwards, on the other hand, the superior cornu of the falciform edge of the saphenous opening, and even Gimbernat's ligament, are relaxed. This, then, is the position in which the limb should be placed during the reduction of the hernia.

As the hernia descends it carries before it the various layers which it meets in the form of coverings. First it pushes before it the peritoneum, and this forms the *hernial sac*. The other coverings from within outwards are—(1) the septum crurale; (2) the wall of the femoral sheath (if it does not burst through one of the apertures in this); (3) the cribriform fascia; (4) and lastly, the superficial fascia and skin.

The crural canal, as we have noted, is surrounded by very unyielding structures. Stricture in cases of femoral hernia is therefore a matter of very common occurrence. The sharp base of Gimbernat's ligament and the superior cornu of the falciform edge of the saphenous opening are especially apt to bring about this condition.

Scarpa's Triangle.—This is the name which is given to the triangular hollow which lies below Poupart's ligament. To bring its boundaries into view the deep fascia must be removed from the anterior aspect of the upper third of the thigh. In the lower two-thirds, the fascia lata should be left undisturbed, so as to maintain as far as possible the natural position of parts.

The *outer boundary* is formed by the *sartorius* as it runs downwards and inwards across the thigh from the anterior superior spine of the ilium ; and the *inner boundary* is constituted by the prominent internal margin of the *adductor longus*. Clean these muscles down to the point where they meet to form the *apex* of the triangle.

Poupart's ligament is the *base* of the triangle.

The *contents* of the space must now be displayed by removing the fatty areolar tissue which surrounds them. The *femoral vessels* should first be cleaned. Remove the remains of the femoral sheath and define the various branches which proceed from the vessels in so far as they are seen within the limits of the triangular space. Be careful not to injure the small twig which springs from the anterior crural nerve, and passes inwards behind the vessels, a short distance below Poupart's ligament, to supply the pectineus muscle. In this part of its course the femoral artery gives off—(1) the *three superficial inguinal* vessels, which have already been observed ramifying in the superficial fascia of the groin ; (2) the *deep external pudic*, which runs inwards over the pectineus ; (3) the large *profunda femoris*.

The *profunda femoris* comes off from the outer side of the femoral artery about one and a-half inches below Poupart's ligament. It inclines downwards and inwards behind the femoral trunk, and soon leaves the space by passing under cover of the adductor longus. The *external* and *internal circumflex arteries* will be seen to arise from the profunda femoris within Scarpa's triangle.

The *external circumflex* should be traced outwards as it passes amongst the branches of the anterior crural nerve to disappear under cover of the outer boundary of the space. The *internal circumflex* is lost to view shortly after its origin by sinking backwards through the floor of the space between the pectineus and psoas muscles. The veins corresponding to these arteries must be cleaned at the same time.

Certain nerves are also to be found in this space, viz.—(1) the *crural branch* of the *genito-crural;* (2) the *external cutaneous*; and (3) the *anterior crural.* The *crural branch* of the *genito-crural* descends in the outermost compartment of the femoral sheath on the outer side of the femoral artery. It pierces the external wall of the sheath and the fascia lata a short distance below Poupart's ligament, and has already been traced to its distribution (p. 321). The *external cutaneous nerve* passes into the thigh behind Poupart's ligament close to the anterior superior spine of the ilium. It soon leaves the triangle by crossing the sartorius and piercing the fascia lata. It has already been traced in its ramifications in the superficial fascia on the outer aspect of the thigh. The *anterior crural nerve* will be detected lying deeply in the interval between the psoas and iliacus muscles, about a quarter of an inch to the outer side of the femoral artery. Insinuate the handle of a knife under the main trunk, so as to raise it above the level of the muscles between which it lies, and render it tense, and then follow the numerous branches into which it breaks up as far as the limits of the space will allow. The minute twig to the pectineus muscle must be looked for with especial care. It passes inwards behind the femoral vessels.

The *floor* of Scarpa's triangle slopes backwards both from the inner and outer boundary of the space. To the inner side of the femoral artery it is formed by the *adductor longus* and the *pectineus;* in some cases a small portion of the *adductor brevis* may be seen between these. To the outer

side of the artery are the *psoas* and *iliacus*. The adductor longus is placed in an oblique plane, the inner border being nearer the surface than the outer border; and thus it is that this muscle not only forms the inner boundary of the triangle but also takes part in the formation of the floor. These muscles should be cleaned in so far as they stand in relation to Scarpa's triangle.

When a transverse section is made through the frozen thigh in the region of Scarpa's triangle the space appears more in the shape of a deep intermuscular furrow, bounded on the inner side by the adductor longus and pectineus, and on the outer side by the sartorius and rectus femoris, whilst behind it is separated from the bone by the ilio-psoas. The femoral vessels and the anterior crural nerve pass downwards in this groove—the profunda femoris being placed very deeply, and the main trunks nearer the surface.

Femoral Artery.—The femoral artery, the great arterial trunk of the lower limb, is the direct continuation of the external iliac. It begins at Poupart's ligament, behind which it enters the thigh, and it extends downwards to the opening in the adductor magnus, through which it gains the popliteal space and becomes the popliteal artery. This opening is situated on the inner aspect of the lower third of the thigh, and the course which the vessel pursues may be marked on the surface, when the thigh is slightly abducted and rotated outwards, by an oblique line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the internal condyle of the femur.

The relations which the artery bears to the femur are important. As it enters Scarpa's triangle it passes from the brim of the pelvis and comes to lie in front of the inner part of the head of the femur, from which it is separated by the psoas muscle. Although its relation to the bone is tolerably intimate, this situation should not be chosen for applying compression. On account of the mobility of the head of the bone there is a liability for the vessel to slip from under the fingers. It is much safer to compress it against the

brim of the pelvis. Below the head of the femur, during the remainder of its course through Scarpa's triangle, the artery is not in direct relation to the bone. It crosses in front of the angular interval between the neck and shaft of the femur. Towards the apex of the space, however, it comes into relation with the inner side of the shaft of the femur, and this position it holds to its termination.

In the present condition of the dissection it is only that part of the femoral artery which traverses Scarpa's triangle which comes under the notice of the dissector. The length of this part varies with the development of the sartorius muscle, and the degree of obliquity with which this crosses the front of the thigh. It measures from three to four inches in length, and is comparatively superficial throughout its entire course. At the apex of the triangle it disappears under cover of the sartorius and takes up a deeper position in the limb.

In Scarpa's triangle the femoral artery is enveloped in its upper part by the femoral sheath, and is separated from the surface by the skin, superficial fascia, and deep fascia, whilst below, it is crossed by the internal cutaneous nerve, which runs along the inner border of the sartorius muscle. *Behind* the vessel is the psoas, and then the pectineus muscle. It rests directly upon the psoas—the femoral sheath and the nerve to the pectineus, as it crosses inwards, alone intervening; but it is separated from the pectineus by an interval occupied by fatty areolar tissue, and here also the profunda artery crosses behind it, and the femoral vein is seen to have a position posterior to it. Upon *the outer side* of the femoral artery is the anterior crural nerve—but not in apposition with it, as a small portion of the psoas intervenes. The *femoral vein* changes its position with reference to the artery, as it is traced from above downwards. In the upper part of the space it lies on the same plane and to the inner side of the artery, but lower down it becomes more deeply placed and gradually assumes a position posterior to the artery.

The *branches* which the femoral artery gives off in Scarpa's triangle have already been enumerated (p. 334). One of these, viz. the deep external pudic, may now be traced to its destination.

The *deep external pudic artery* is a small twig which arises from the inner side of the femoral, a short distance below Poupart's ligament. It extends inwards upon the pectineus and adductor longus muscles, and, piercing the fascia lata, ends, according to the sex, in the integument of the scrotum or labium pudendi.

Dissection.—The fascia lata may now be removed from the lower two-thirds of the thigh. This can best be effected by dividing it along the middle line of the limb, and throwing it outwards and inwards. Preserve undisturbed the thickened band of fascia on the outer side of the thigh.

In cleaning the sartorius muscle several of the nerves of the thigh will be found intimately related to it, and must be carefully dissected. The middle cutaneous nerve frequently pierces its upper border, and then proceeds downwards in front of it; the anterior branch of the internal cutaneous crosses it at a lower level, whilst the posterior branch of the same nerve is carried downwards along its posterior border. Near the knee it lies over the long saphenous nerve, which ultimately comes to the surface between it and the gracilis. A short distance above this it is pierced by the patellar branch of the long saphenous. Lastly, about the middle of the thigh there is formed under cover of the sartorius an interlacement of fine nerve twigs derived from the posterior branch of the internal cutaneous, the long saphenous, and the obturator. On raising the sartorius from subjacent parts this must be looked for.

The different portions of the quadriceps extensor muscle must also be cleaned, and the branches which the anterior crural nerve gives to them, as well as the

descending branch of the external circumflex artery, traced to their terminations.

Sartorius.—The sartorius is a long slender muscle, which arises from the anterior superior spine of the ilium and the upper part of the notch on the anterior border of the bone immediately below. It crosses the front of the upper third of the thigh obliquely, and gaining the inner side of the limb, it takes a nearly vertical course downwards to a point beyond the inner prominence of the knee. Here it turns forwards, and ends in a thin, expanded aponeurotic tendon, which is inserted into the inner surface of the shaft of the tibia, behind the anterior tubercle. By its lower border this tendon is connected with the fascia of the leg, whilst by its upper border it is joined to the capsule of the knee-joint.

In its upper oblique part the sartorius muscle forms the outer boundary of Scarpa's triangle, and lies in front of the iliacus, the rectus femoris, and the adductor longus muscles. Below this, it is placed over the femoral vessels as far as the opening in the adductor magnus. At its insertion its expanded tendon lies in front of, and covers, the tendons of insertion of the gracilis and semitendinosus, but is separated from them by a bursa.

Hunter's Canal.—When the femoral artery leaves Scarpa's triangle it is continued downwards on the inner side of the thigh, in a deep furrow, which is bounded on the outer side by the vastus internus muscle, and on the inner side by the adductor muscles. If this furrow be traced upwards, it will be seen to run into the deeper, wider, and more apparent hollow, which has been described as Scarpa's space. Further, this intermuscular recess is converted into a canal, triangular on transverse section, by a strong fibrous membrane which stretches across it, and upon the surface of which the sartorius muscle is placed. The tunnel thus formed is called 'Hunter's Canal.' When the fibrous expansion which closes in the canal is traced upwards it is seen to

become thin and ill-defined as it approaches Scarpa's triangle; when traced in the opposite direction, however, it becomes dense and strong, and opposite the opening in the adductor magnus it ends in a thick, sharply-defined margin. It stretches from the tendons of the adductor longus and the adductor magnus on the inner side to the

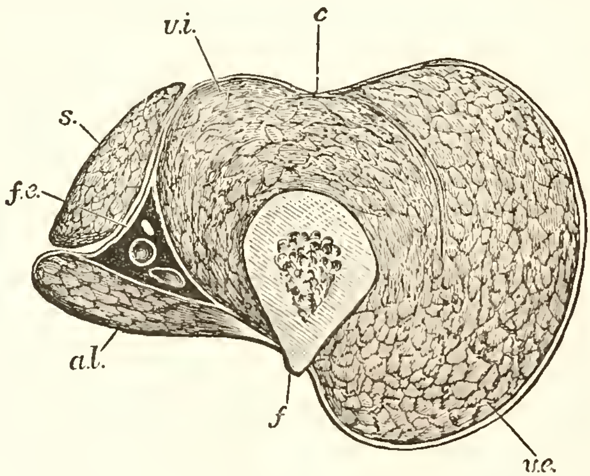

FIG. 62.

Transverse Section through Hunter's Canal.

f. Femur.
a. l. Adductor longus.
f. e. Femoral vessels and long saphenous nerve in the canal.
s. Sartorius.
v. i. Vastus internus.
c. Crureus.
v. e. Vastus externus.

vastus internus on the outer side. In its lower part the posterior wall of the canal, where it is formed by the adductor magnus, presents a deficiency or aperture which leads backwards into the popliteal space. The appearance and construction of this aperture will be studied at a later stage. It is called *the opening in the adductor magnus.*

The femoral vessels and the long saphenous nerve traverse Hunter's canal. In this part of its course the artery gives off some muscular twigs and the anastomotica magna branch. The femoral vessels leave the canal at its lower end by inclining backwards through the opening in the

adductor magnus and entering the popliteal space. The long saphenous nerve, accompanied by the superficial branch of the anastomotica magna artery, escape from the canal by passing under cover of the lower sharp margin of the fibrous expansion which closes it in. They can be seen in the present stage of the dissection in this situation.

The fibrous expansion which is stretched across Hunter's canal should now be divided, in order that the arrangement of the parts within the canal may be studied.

Lower Portion of the Femoral Artery.—The entire length of the femoral artery is now exposed. Below the apex of Scarpa's triangle it enters Hunter's canal, and is

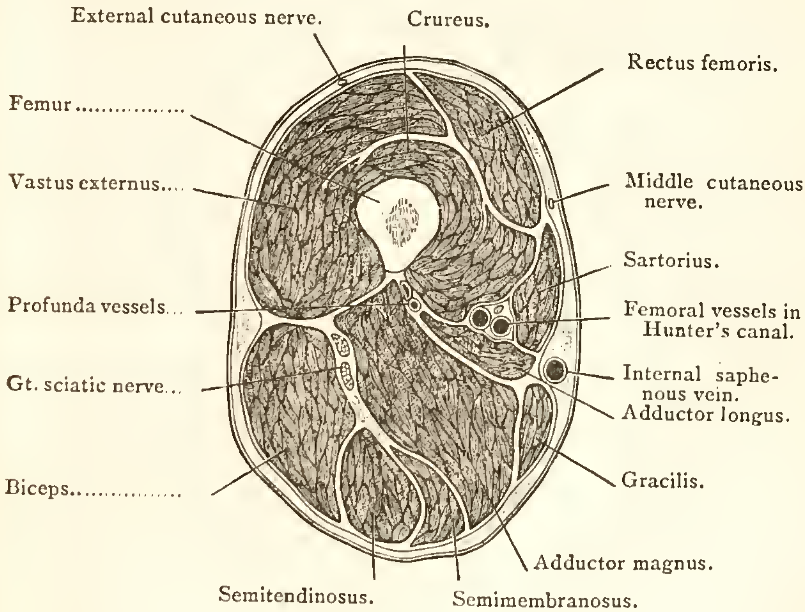

FIG. 63.

Transverse Section through the middle of the Thigh. The relationship of the parts in Hunter's Canal is seen.

separated from the surface by the fibrous expansion which closes the canal, the sartorius muscle, the fascia lata, and the integument. The long saphenous nerve at first

lies to the outer side of this portion of the vessel and then in front of it. From above downwards the artery rests upon the pectineus, the adductor brevis, the adductor longus, and the adductor magnus. In its upper part, however, it is separated from these muscles by the femoral vein, which lies behind it; lower down, the vein, which inclines outwards, comes to lie on its outer side. The relation of parts in the lower portion of Hunter's canal is seen in figs. 62, 63. The two vessels are placed side by side, whilst the long saphenous nerve is in front of the artery.

From the femoral artery, as it traverses Hunter's canal, proceed muscular twigs and the anastomotic branch.

The *muscular branches* are irregular in number and in their mode of origin. They supply the vastus internus, the adductor longus, and the sartorius.

The Anastomotic Artery springs from the femoral trunk a short distance above the point where it enters the popliteal space by passing through the opening in the adductor magnus. It almost immediately divides into a superficial and a deep branch: very frequently, indeed, these branches take separate origin from the femoral artery.

The *superficial branch* accompanies the long saphenous nerve, and leaves Hunter's canal by passing under cover of the lower border of the fibrous expansion which is stretched over the canal. On the inner side of the knee it appears between the gracilis and sartorius, and it ends in branches to the integument on the inner aspect of the upper part of the leg.

The *deep branch* enters the substance of the vastus internus and proceeds downwards in front of the tendon of the adductor magnus. It gives some twigs to the vastus internus and others which spread out over the upper and inner aspect of the knee-joint and anastomose with branches of the internal articular arteries. One well-marked branch

runs outwards above the patella to anastomose with the superior external articular artery.

The Femoral Vein is the direct continuation upwards of the popliteal vein. It begins at the opening in the adductor magnus, through which it enters Hunter's canal, whilst above it passes behind Poupart's ligament, and becomes continuous with the external iliac vein. It accompanies the femoral artery, but the relations of the two vessels to each other differ at different stages of their course. In the lower part of Hunter's canal the vein lies on the outer side of the artery, but it inclines inwards as it ascends, and in the upper part of the thigh it lies on its inner side and on the same plane. The crossing from one side to the other takes place behind the artery and is very gradual, so that for a considerable distance the femoral vein lies directly behind the femoral artery. For a distance of two inches below Poupart's ligament it is enclosed within the femoral sheath, of which it occupies the middle compartment.

In its journey up the thigh the femoral vein receives tributaries which for the most part correspond with the branches of the femoral artery. At the saphenous opening it is joined by the internal saphenous vein. The dissector should slit it open with the scissors. Several valves will then be seen. One invariably is found at the entrance of the vein which corresponds to the profunda artery.

Anterior Crural Nerve.—The anterior crural nerve is a large nerve which arises within the abdomen from the lumbar plexus. It enters the thigh by passing downwards in the interval between the psoas and iliacus muscles and behind Poupart's ligament and the fascia iliaca. In the upper part of the thigh it lies to the outer side of the femoral artery, and is separated from it by a small portion of the psoas muscle and the femoral sheath. A short distance below Poupart's ligament it divides into an anterior and a posterior portion, which at once resolve themselves into

a large number of cutaneous and muscular branches. The following is a list of these:—

Anterior division,	Muscular branches,	To the pectineus.
		,, sartorius.
	Cutaneous branches,	Middle cutaneous.
		Internal cutaneous.
Posterior division,	Muscular branches,	To the rectus femoris.
		,, vastus internus.
		,, vastus externus.
		,, crureus.
		,, sub-crureus.
	Cutaneous branch,	. Long saphenous.
	Articular branches.	

With the exception of the long saphenous, which is distributed upon the inner side of the leg and foot, the distribution of the cutaneous branches of the anterior crural has been already examined (p. 321.)

The *nerve to the pectineus* arises a short distance below Poupart's ligament, and turns inwards behind the femoral vessels to reach its destination. The *branches to the sartorius* are two or three in number. As a rule they take origin by a common trunk with the middle cutaneous nerve.

The *middle cutaneous nerve* sometimes pierces the upper border of the sartorius. It divides into two branches which perforate the fascia lata about three or four inches below Poupart's ligament.

The *internal cutaneous nerve* inclines downwards and inwards, and crosses in front of the femoral artery. It divides into an anterior and a posterior portion, which become superficial at different levels on the inner side of the limb. From the trunk of the nerve a few cutaneous twigs are given to the skin over the upper and inner part of the thigh. The *anterior branch* crosses the sartorius muscle and makes its appearance through the fascia lata in the lower part of the thigh, a short distance in front of the saphenous vein. The *posterior* branch runs downwards along the posterior border of the sartorius, and pierces the deep

fascia on the inner side of the knee behind that muscle and the long saphenous nerve.

A short distance below the middle of the thigh the posterior branch of the internal cutaneous nerve forms, with filaments from the obturator nerve and the long saphenous nerve, a plexiform interlacement, the *sartorial plexus*, which is placed under the sartorius muscle, as it lies over Hunter's canal. The twig from the obturator nerve appears at the inner border of the adductor longus.

The *long saphenous nerve* is the largest branch of the anterior crural. It springs from the posterior division of that nerve and extends downwards on the outer side of the femoral artery. Entering Hunter's canal with the femoral vessels it comes to lie in front of the artery. At the lower end of the canal it emerges, by passing under cover of the sharply defined border of the fibrous expansion which stretches between the vastus internus and the adductor muscles, and, accompanied by the superficial branch of the anastomotic artery, it escapes from under cover of the sartorius and pierces the deep fascia at the inner side of the knee. It gives off the *patellar branch* after it quits Hunter's canal. This branch pierces the sartorius and appears on the surface of the fascia lata on the inner side of the knee.

Several large branches of the posterior part of the anterior crural nerve enter the four factors which compose the great quadriceps extensor muscle of the thigh. From certain of these articular filaments are given to the hip and knee-joints.

The *branch to the rectus femoris* sinks into the deep surface of this muscle. It supplies an articular twig to the hip-joint. The large *branch to the vastus internus* accompanies the long saphenous nerve, and enters with it the upper part of Hunter's canal. It can readily be distinguished from its sinking into the inner aspect of the vastus internus about the middle of the thigh. In the substance of this muscle it extends downwards, and near the knee joins the deep branch of the anastomotic artery.

It gives an articular nerve to the synovial membrane of the knee-joint. The *nerve to the vastus externus* is associated with the descending branch of the external circumflex artery. Very frequently it gives an articular twig to the knee-joint. The *nerves to the crureus* are two or three in number, and they sink into its anterior surface. The innermost of these is a long slender nerve, which can be traced downwards under the anterior border of the vastus internus to the subcrureus. Its terminal twigs are given to the synovial membrane of the knee-joint.

One filament then from the anterior crural goes to the hip-joint; two, and frequently three, filaments go to the knee-joint.

Ilio-tibial Band of Fascia Lata.—The thick band of fascia lata on the outer side of the thigh which receives this name should now be examined, and its connections ascertained. It has been preserved for this purpose. Inferiorly it is attached to the outer tuberosity of the tibia and to the head of the fibula. On tracing it upwards on the outer surface of the vastus externus it will be observed to split at the junction of the middle and upper thirds of the thigh into two lamellæ—a superficial and a deep. The tensor fasciæ femoris is enclosed between these layers, and when they are disengaged from its surfaces the muscle will be seen to be inserted into the fascia at the angle of splitting. The *superficial lamina* of the ilio-tibial band is attached above to the crest of the ilium, and is continuous posteriorly with the gluteal aponeurosis as it covers the gluteus medius. The *deep lamina* can be followed upwards on the outer surface of the rectus femoris to the capsule of the hip-joint, with the upper and outer part of which it blends. It is also connected with the reflected tendon of the rectus femoris. This layer is perforated by the ascending twigs of the external circumflex artery.

Tensor Fasciæ Femoris.—This is a small muscle which is placed on the outer and anterior aspect of the upper

third of the thigh. It lies between the two lamellæ of the ilio-tibial band of fascia, in the interval between the sartorius muscle in front and the gluteus medius muscle behind. On turning the muscle outwards so as to display its deep surface a little dissection will bring into view its nerve of supply which comes from the *superior gluteal nerve*. This nerve however, has in all probability been already exposed in the dissection of the gluteal region. A few arterial twigs from the external circumflex also sink into its deep surface.

The *tensor fasciæ femoris* arises from a small portion of the anterior part of the crest of the ilium ; from the upper part of the notch below the anterior superior spine of the ilium ; and by some fibres from the aponeurosis covering the gluteus medius. It extends downwards with a slight inclination backwards, and is inserted into the ilio-tibial band of fascia lata at its angle of splitting.

The External Circumflex Artery is the largest branch which proceeds from the profunda femoris. It arises near the origin of the latter from the femoral artery, and runs outwards between the divisions of the anterior crural nerve and under cover of the sartorius and rectus femoris muscles. It ends by dividing into ascending, transverse, and descending branches.

The *ascending branch* reaches the dorsum ilii by passing under cover of the tensor fasciæ femoris. Its terminal twigs anastomose with the gluteal artery. The *transverse branch* is of small size and passes to the deep surface of the vastus externus. It reaches the back of the thigh, and inosculates with the internal circumflex and the first perforating arteries. The *descending branch* gives twigs to the crureus and rectus femoris and one long branch, which may be traced downwards amid the fibres of the vastus externus to the knee, where it anastomoses with the superior external articular artery.

The Intermuscular Septa.—Divide the *ilio-tibial* band of fascia lata below the point at which it splits to enclose the

tensor fasciæ femoris. This is done so as to obtain a better view of the vastus externus, and in order to demonstrate satisfactorily the external intermuscular septum. Take hold of the lower portion of the ilio-tibial band, and draw it forcibly outwards; at the same time push inwards the vastus externus muscle, and a strong fibrous septum will be seen passing inwards from the fascia lata towards the linea aspera. This is the *external intermuscular septum* of the thigh, a partition interposed between the vastus externus and the short head of the biceps. Follow it upwards and downwards with the finger. The fibres of the vastus externus are seen arising from it, but little difficulty will be experienced in making out its attachment to the linea aspera of the femur. It extends in an upward direction as far as the insertion of the gluteus maximus, whilst below it reaches the external tuberosity of the lower end of the femur. Immediately above the external condyle of the femur it is pierced by the *superior external articular* vessels and nerve. The *internal intermuscular septum* is interposed between the adductors and the vastus internus, and should also be examined. It is thin in comparison with the external septum.

Quadriceps Extensor Cruris.—This muscle is composed of four portions. The rectus femoris, which is placed on the front of the thigh, is quite distinct from the others, except at its insertion; the vastus externus, the crureus and the vastus internus clothe the shaft of the femur on its outer, inner, and anterior aspects, and are more or less blended with each other.

The Rectus Femoris arises by two tendinous heads of origin, which may be exposed by dissecting deeply in the interval between the iliacus and tensor fasciæ femoris. The *anterior* or *straight* head springs from the anterior inferior spine of the ilium: the *posterior* or *reflected head* arises from a marked impression on the outer surface of the ilium, immediately above the upper part of the rim of

the acetabulum, and is connected both with the capsule of the hip-joint and the deep lamina of the ilio-tibial band of fascia lata. The two heads of origin of the rectus femoris join at a right angle immediately beyond the margin of the acetabulum, and form a strong flattened tendon, which gives place to a fusiform, fleshy belly. The tendon of origin spreads out on the anterior surface of the muscle in its upper part in the form of an aponeurosis. The superficial fleshy fibres of the muscle have a bipenniform arrangement, whilst the deep fibres run in a longitudinal direction. About three inches above the knee-joint the rectus femoris ends in a strong tendon of insertion, which is prolonged for some distance upwards on its deep surface in the form of an aponeurosis. As it nears the patella, this tendon is joined by the other tendons of the quadriceps, and through the medium of a common tendon finds insertion into the upper border of that bone.

The Vastus Externus forms the prominent muscular mass on the outer side of the thigh. Its surface is covered by a glistening aponeurosis. The descending branch of the external circumflex artery constitutes the best guide to its anterior border, and when this is raised it will be seen that the muscle lies upon and is partially blended with the crureus.

The vastus externus arises—(1) from the upper part of the anterior intertrochanteric line; (2) from the front of the great trochanter, anterior to the insertion of the gluteus minimus; (3) from the root of the great trochanter below the insertion of the gluteus medius; (4) from the outer part of the gluteal ridge in front of the insertion of the gluteus maximus; (5) from the upper part of the linea aspera; and (6) from the external intermuscular septum. The fleshy fibres are for the most part directed downwards and forwards. By means of the common tendon of insertion the muscle gains insertion into the patella, and at the same time gives an expansion to the capsule of the knee-joint.

The Vastus Internus is intimately connected with the crureus, but not to such an extent as might be inferred from a superficial inspection. In its upper part the anterior border, which is fleshy, is either contiguous or blended with the crureus; below, the anterior border is tendinous and overlaps the crureus, but it is not fused with it. 'A line drawn from the middle of the anterior intertrochanteric line downwards and slightly outwards to the middle of the upper border of the patella will define accurately the thick anterior border of the vastus internus.'—(Williams.) Divide the rectus femoris about its middle, and pull the lower part forcibly downwards. The narrow interval between the tendons of the crureus and vastus internus will then become apparent, and may be followed upwards. A still further guide is the long, slender nerve of supply to the subcrureus, which runs along the inner edge of the crureus. When the anterior border of the vastus internus is raised from the crureus the inner surface of the shaft of the femur will be seen to be perfectly bare. No muscular fibres arise from this bony surface. The fleshy mass of the vastus internus may now, with advantage, be divided transversely about two inches above the patella. The muscle can then be thrown inwards, and its origin studied.

The vastus internus arises—(1) from the lower part of the anterior intertrochanteric line of the femur; (2) from the line leading from this, below the small trochanter, to the linea aspera; (3) from the inner lip of the linea aspera; (4) from the upper part of the internal supracondyloid line as low down as the opening in the adductor magnus; (5) from the rounded tendon of the adductor magnus. The fleshy fibres are directed downwards and forwards, and end in the common tendon of the quadriceps muscle. By this it is inserted into the patella, and becomes connected with the capsule of the knee-joint.

The Crureus covers the anterior and outer aspects of the shaft of the femur, from both of which, as well as from the

lower part of the external intermuscular septum, it takes origin. It is inserted into the patella through the medium of the common tendon.

Common Tendon of the Quadriceps.—It should now be noticed that the *common tendon* of the quadriceps muscle closes the knee-joint above the patella. It is inserted into the upper border of that bone, and is intimately connected with the capsule of the knee-joint. Some fibres are carried downwards into the ligamentum patellæ upon the surface of the patella. A pouch of synovial membrane is prolonged upwards beyond the level of the patella, between the quadriceps and the bone. Into this some of the lower and deeper fasciculi of the crureus muscle are inserted. They constitute the *subcrureus muscle.* The crureus should be divided in a vertical direction, so as to bring this little muscle into view, and at the same time the long, slender nerve-filament which runs along the inner border of the crureus, may be traced to it and the synovial membrane of the knee-joint.

The *ligamentum patellæ*, which connects the patella with the anterior tubercle of the tibia, and through which the quadriceps is attached to that bone, will be studied in connection with the knee-joint.

INNER SIDE OF THE THIGH.

The group of adductor muscles on the inner aspect of the thigh, together with the blood-vessels and nerves associated with them, must next be dissected. In this dissection the following are the structures which are displayed :—

Muscles,	Pectineus. Adductor longus. Adductor brevis. Adductor magnus. Gracilis. Obturator externus.
Arteries,	Profunda femoris and its branches. Obturator.
Nerves.	The two divisions of the obturator. Occasionally the accessory obturator.

The adductor muscles are disposed in three strata. The superficial stratum is formed by the adductor longus and the pectineus, which lie in the same plane. Above they are placed side by side, but below, as they approach their insertions, they are separated from each other by an interval. The second stratum is formed by the adductor brevis; and the third, or deep layer, by the adductor magnus. The gracilis muscle, also an adductor, extends along the inner aspect of the thigh. It is a long, strap-like muscle, applied against the adductor brevis and adductor magnus. Interposed between these muscular layers, and affording a means of separating the one from the other, are the two divisions of the obturator nerve. The anterior division is placed between the superficial and middle layers, whilst the posterior division lies between the middle and deep layers. In other words, the two divisions of the nerve are separated from each other by the adductor brevis, which intervenes between them. At the lower border of the adductor longus, a fine branch from the anterior division of this

nerve, makes its appearance to take part in the formation of the sartorial nerve-plexus already dissected. The profunda artery and its branches are also to be followed. For a part of its course this vessel is placed between the anterior and middle muscular strata.

The Adductor Longus is placed on the inner side of the pectineus. It is somewhat triangular in shape, being narrow at its origin and expanded at its insertion. It arises by a short, but strong tendon from the front of the body of the pubis, immediately below the crest, and it is inserted into the inner lip of the linea aspera of the femur by a thin, tendinous expansion.

The adductor longus may now be reflected. Divide it close to the round tendon of origin, and throw it outwards. In doing this be careful of the anterior division of the obturator nerve, which lies under cover of it, and gives to it its nerve of supply. On approaching the linea aspera of the femur its aponeurotic tendon will be found intimately connected with the vastus internus in front and with the adductor magnus behind. Separate it from these as far as possible, in order that the profunda femoris vessels may be fully displayed as they proceed behind it.

Arteria Profunda Femoris.—This large vessel is the chief artery of supply to the muscles of the thigh. It arises in Scarpa's triangle from the outer and posterior aspect of the femoral artery, about an inch and a-half below Poupart's ligament. At first it is placed on the iliacus, but it inclines inwards as it proceeds downwards, and thus it crosses behind the femoral artery, and comes to lie on the pectineus. Reaching the upper border of the adductor longus, it passes behind that muscle, and is continued downwards close to the shaft of the femur upon the adductor brevis and adductor magnus. Numerous large branches spring from the profunda femoris, so that it rapidly diminishes in size. Ultimately it is reduced to a fine terminal twig, which

turns backwards, through the adductor magnus, and is termed the *fourth perforating artery*. The following, then, are the relations of the profunda femoris:—(1) It lies on the iliacus to the outer side of the femoral artery. (2) It rests on the pectineus, behind the femoral artery, but separated from it by the profunda femoris and the femoral veins. (3) It is placed on the adductor brevis, and lower down on the adductor magnus; the adductor longus lies in front of it, and separates it from the femoral artery. (4) The terminal twig, called the fourth perforating artery, pierces the adductor magnus at the junction of the middle and lower thirds of the thigh.

The *branches* which spring from the profunda femoris are: the two circumflex arteries, the four perforating arteries, and some muscular branches.

The *external circumflex* arises from the outer aspect of the profunda, close to its origin. It has already been followed to its distribution. The *internal circumflex*,* which takes origin at the same level, but from the inner and back aspect of the profunda, will be studied when the pectineus muscle is reflected. The *muscular branches* are irregular both in origin and size. They supply the adductor muscles, and may give twigs to the hamstring muscles.

The Perforating Arteries arise in series from the main trunk, and pass backwards through the adductor muscles to the back of the thigh. They may be recognized from the close relation which they bear to the linea aspera of the femur. The *first perforating artery* comes off at the level of the lower border of the pectineus. It proceeds backwards through the adductor brevis and adductor magnus. The *second perforating artery* takes origin a short distance lower down, or perhaps by a common trunk, with the first perforating. It pierces the same muscles, viz. the

* The internal circumflex frequently arises from the common femoral trunk.

adductor brevis and adductor magnus. The *third perforating* springs from the profunda below the adductor brevis, and passes backwards through the adductor magnus. The *fourth perforating*, as we have noted, is the terminal branch of the profunda femoris, and pierces the adductor magnus.

The *chief nutrient artery* to the femur may come from either the second or the third perforating branch. A *second nutrient twig* is frequently derived from the fourth perforating artery.

When the adductor magnus is more fully exposed it will be seen that the perforating arteries, as they pierce its tendon, have a series of fibrous arches thrown over them.

The Pectineus Muscle is placed between the adductor longus and the ilio-psoas. It is flat and somewhat broader at its origin from the brim of the pelvis than at its insertion into the femur. It has a fleshy origin, between the pubic spine and the ilio-pectineal eminence, from the ilio-pectineal line, and also slightly from the surface of bone in front. Some fibres are likewise derived from Gimbernat's ligament. It descends obliquely outwards and backwards, and gains insertion into the femur behind the small trochanter, and to a certain extent also into the line which leads from this prominence down to the linea aspera.

The pectineus may be detached from its origin, and thrown downwards and outwards. In separating the muscle from the pubis the dissector must bear in mind that in some cases an *accessory obturator nerve* descends into the thigh, over the brim of the pelvis, and under cover of its outer margin. Care must also be taken not to injure the anterior division of the obturator nerve which lies behind it, or the internal circumflex artery which passes backwards in contact with its outer border.

The accessory obturator nerve when present arises within the abdomen from the obturator trunk near its origin. In the thigh it gives a branch to the hip-joint and joins the anterior division of the obturator nerve. Very rarely a twig to the pectineus is given either by it or by the trunk of the obturator nerve itself.

The Internal Circumflex Artery arises from the inner and back aspect of the profunda femoris at the same level as the origin of the external circumflex. It proceeds backwards between the psoas and pectineus, and then between the upper border of the adductor brevis and the obturator externus to gain the back of the limb. Close to the small trochanter of the femur it divides into two terminal branches—a transverse and an ascending. From the main trunk before it divides are given off several *muscular branches* to the adjoining muscles and an *articular branch,* which enters the hip-joint through the cotyloid notch.

The *terminal branches* of the internal circumflex have already been examined in the dissection of the gluteal region. The *transverse branch* is carried backwards between the contiguous borders of the adductor magnus and the quadratus femoris and anastomoses with the first perforating and sciatic arteries. The *ascending branch* runs upwards on the obturator externus, and under cover of the quadratus femoris. It appears in the interval between the quadratus femoris and inferior gemellus and anastomoses with the gluteal and sciatic arteries.

In every region of the thigh the dissector has met with branches of the femoral artery. It is well now that he should revert to this vessel and study its branches systematically. The following Table may aid him in doing this :—

Femoral.	Superficial pudic.	Superficial inguinal.	
	Superficial epigastric.		
	Superficial circumflex iliac.		
	Deep external pudic.		
	Profunda, or deep femoral.	External circumflex.	
		Internal circumflex.	
		First perforating.	
		Second perforating.	Nutrient.
		Third perforating.	
		Fourth perforating, or terminal.	
	Muscular.		
	Anastomotica magna.		

The Adductor Brevis lies behind the adductor longus and the pectineus. It arises below the origin of the adductor longus from the anterior aspect of the body and the descending ramus of the pubis. As it descends it inclines backwards and outwards, and it is inserted behind the pectineus into the whole length of the line which extends from the small trochanter to the linea aspera.

Reflect the adductor brevis by cutting it close to its origin, and throwing it downwards and outwards. The posterior division of the obturator nerve is now exposed, and should be traced upwards to the thyroid foramen, and downwards to its distribution upon the adductor magnus.

Obturator Nerve.—The obturator nerve is a branch of the lumbar plexus, and escapes from the pelvis by passing with its companion vessels through the upper part of the thyroid foramen of the innominate bone. While still within the foramen it divides into an anterior and a posterior division.

The *anterior division* of the obturator nerve enters the thigh over the upper border of the obturator externus muscle, and proceeds downwards upon the anterior surface of the adductor brevis. In front of it are the pectineus and adductor longus muscles. It gives branches to three muscles, viz. the adductor longus, the adductor brevis, and the gracilis. Very rarely it will be observed to supply a twig to the pectineus. In addition to these it supplies an *articular branch* to the hip-joint, a fine twig which appears at the lower border of the adductor longus to join the sartorial plexus, and a *terminal twig* which goes to the femoral artery, and breaks up into fine filaments upon its walls.

The *posterior division* of the obturator nerve as it enters the thigh pierces the upper border of the obturator externus. It extends downwards between the adductor brevis and the adductor magnus, and is chiefly expended in the supply of the latter muscle. It gives also, however, a branch to the obturator externus and an *articular branch*

to the knee-joint. The latter branch pierces the lower part of the adductor magnus close to the linea aspera, and has already been seen in the popliteal space lying upon the popliteal artery.

The Gracilis is a long, strap-like muscle, which is situated along the inner aspect of the thigh and knee. It springs by a thin tendon from the lower half of the body of the pubis, close to the symphysis, and also from the upper half of the pubic arch. It ends in a slender, rounded tendon, which inclines forwards below the knee, and then expands to find insertion into the upper part of the inner surface of the tibia, under cover of the tendon of the sartorius, and at a higher level than the insertion of the semitendinosus. A synovial bursa separates the expanded tendon of the gracilis from the internal lateral ligament of the knee-joint, and is prolonged above it so as to intervene between it and the tendon of the sartorius.

The Adductor Magnus is one of the most powerful muscles of the thigh. It forms a flat fleshy mass, which springs from the anterior surface of the entire length of the pubic arch, and from the lower part of the tuberosity of the ischium. *The fibres which arise from the pubic arch* spread out as they approach the back of the femur. The upper fibres are nearly horizontal in their direction; below this they descend with increasing degrees of obliquity. They are inserted into the posterior surface of the femur, immediately internal to the gluteal ridge, into the linea aspera, and into a small portion of the upper part of the internal supracondyloid ridge. *The fibres which take origin from the ischial tuberosity* descend almost vertically and form the thick inner border of the muscle. In the lower third of the thigh they end in a strong, rounded tendon, which is inserted into the adductor tubercle on the inner tuberosity of the femur. This tendon is further attached to the femur by the internal intermuscular septum which stretches between it and the internal supracondyloid

line. Close to the linea aspera the dissector will notice that fibrous arches are formed in connection with the insertion of the adductor magnus for the passage of the perforating arteries. The opening through which the femoral artery enters the popliteal space lies in series with these. It is a gap between the two portions of the muscle, and is situated in the lower third of the thigh.

The adductor magnus has a double nerve supply. Behind, it is supplied by branches from the great sciatic, whilst in front it receives the greater part of the posterior division of the obturator.

The adductor magnus should now be detached from its origin, in order that the obturator externus muscle and the obturator artery may be more fully examined.

Obturator Externus—Obturator Artery.—The *obturator externus* is a flat, fan-shaped muscle, which is placed over the front of the thyroid foramen of the innominate bone. It springs from the inner half of the membrane which closes the foramen, and also from the inner and lower part of its bony margin. It proceeds backwards and outwards below the neck of the femur and the capsular ligament of the hip-joint, and ends in a stout tendon which obtains insertion into the digital fossa at the root of the great trochanter. This tendon has already been noticed in the dissection of the gluteal region.

The *obturator artery* appears in the thigh through the upper part of the thyroid foramen of the innominate bone. It at once divides into two terminal branches, which diverge from each other, and form an arterial circle upon the thyroid membrane, under cover of the obturator externus. This muscle must therefore be detached in order that these vessels may be followed. Both branches give twigs to the neighbouring muscles, whilst the *outer branch* (*i.e.* the branch which runs round the outer side of the foramen) sends an *articular twig* through the cotyloid notch of the acetabulum into the hip-joint. When the joint is opened

this twig may be followed, in a well-injected subject, along the ligamentum teres into the head of the femur.

Psoas and Iliacus—These muscles arise within the abdomen and enter the thigh behind Poupart's ligament. A tendon appears on the outer side of the psoas, and into this the fibres of the iliacus are for the most part inserted. The conjoined tendon of the ilio-psoas is implanted into the small trochanter of the femur, but a certain proportion of the fleshy fibres of the iliacus obtain direct insertion into the shaft of the femur below and in front of that prominence.

Dissection.—Divide the femoral vessels, and the anterior crural nerve, about an inch below Poupart's ligament, and having tied them together with twine throw them downwards. Now cut through the sartorius and the rectus femoris about two inches from their origin and turn them aside. The tendon of the ilio-psoas must next be detached from its insertion and the muscle thrown upwards. This will expose the anterior surface of the capsule of the hip-joint. An intervening *bursal sac* will also be displayed. Open this and ascertain its extent by introducing the finger. It facilitates the play of the ilio-psoas upon the front of the hip-joint, and in some rare cases it will be found to be directly continuous with the synovial membrane of this articulation through an aperture in the capsular ligament. The intimate connection which exists between the capsule of the hip-joint and the tendon of the gluteus minimus, the reflected head of the rectus femoris, and the deep layer of the ilio-tibial band, should be noticed. Lastly, reflect the tensor fasciæ femoris, and carefully clean the capsule of the hip-joint.

HIP-JOINT.

The hip-joint is the most perfect example of an enarthrodial or ball and socket joint in the body. It does not allow so free a range of movement as that which takes place at the shoulder-joint, but what it loses in this respect it gains in strength and stability. Its great strength and security depend: (1) upon the depth of the cotyloid cavity and the thorough manner in which the head of the femur is received into it; (2) upon the tension and power of the ligaments; (3) upon the length and oblique direction of the neck of the femur; and (4) upon atmospheric pressure.

The ligaments in connection with the hip-joint are:—

1. Capsular.
2. Ligamentum teres.
3. Cotyloid.
4. Transverse.

The capsular ligament and the ligamentum teres are attached to both bones, entering into the construction of the joint. The transverse and the cotyloid ligaments are connected with the acetabular cavity; the former partially fills up the notch or deficiency in its inferior part, whilst the latter surrounds its circumference in a ring-like fashion, and serves to still further deepen it.

Capsular Ligament.—This is exceedingly strong, and surrounds the joint on all sides. *Superiorly*, it is attached around the acetabulum; above and behind, directly to the innominate bone, just outside the rim of the cavity; in front, to the outer aspect of the cotyloid ligament; and below, to the transverse ligament. *Inferiorly*, it clasps the neck of the femur. In front, it is attached to the whole length of the anterior intertrochanteric line, and to the root of the great trochanter. This attachment is very firm and strong. Behind and below, it falls short of the posterior intertrochanteric line by about half an inch, and it presents a weak attachment to the posterior and inferior surfaces of the neck of the femur.

If the capsule of the hip-joint has been carefully cleaned it will be seen that the fibres which compose it run in two different directions. The majority pass in a longitudinal direction from one bone to the other; others, however, may be observed to take a more or less transverse or circular course. The latter are only seen to advantage on the posterior aspect of the capsule, whilst the longitudinal fibres are massed on the front of the joint. Certain thickened portions of the capsule, with more or less distinct attachments, are described as the *accessory ligaments* of the joint. These are:—

1. Ilio-femoral.
2. Pubo-femoral.
3. Ischio-capsular.
4. The zonular band.

The *ilio-femoral band* is placed over the front of the articulation, and constitutes the thickest and most powerful part of the capsule. It springs from the anterior inferior spine of the ilium, and from a depressed surface on the bone immediately to the outer side of this. As it is traced downwards in the capsule, it divides into two limbs, which diverge slightly from each other. The outer portion is implanted into the upper part of the anterior intertrochanteric line, close to the great trochanter; the inner portion, longer and almost vertical in direction, descends to find attachment into the lower end of the anterior intertrochanteric line. The interval between these two diverging parts of this ligament is occupied by a thinner portion of the capsule. The ilio-femoral band is sometimes called the Y-*shaped ligament*, but in making use of this term remember that the shape it presents is that of an inverted λ.

The *pubo-femoral band* is the name applied to several fasciculi of no great strength, which spring from the pubic bone and the thyroid membrane, and join the lower and anterior aspect of the capsule. In cases where the bursa under the ilio-psoas is continuous with the synovial membrane of the joint the aperture of communication is placed between this band and the ilio-femoral band. The *ischio-*

capsular band is stronger. It takes origin from the ischium below the acetabulum, and passes into the lower and posterior aspect of the capsule. The *zonular band* is composed of circular fibres, and will be observed on the posterior aspect of the capsule. It encircles the neck of the femur behind and below, but is lost as it is traced forwards towards the upper part and the front of the capsule.

The dissector has already observed the close connexion which is exhibited between the capsule of the hip-joint and the tendons of the gluteus minimus, and the reflected head of the rectus. Reinforcing fibres are contributed to the capsule by both of these tendons.

Movements permitted at the Hip-joint.—Before the capsule of the joint is opened the range of movement which is permitted at the hip-joint should be tested. *Flexion*, or forward movement, is very free, and is only checked by the anterior surface of the thigh coming into contact with the abdominal wall. *Extension*, or backward movement, is limited by the ilio-femoral band. This powerful ligament has a most important part to play in preserving the upright attitude with the least possible expenditure of muscular exertion. In the erect posture the line of gravity falls slightly behind the line joining the central points of the two hip-joints. In this position the ilio-femoral bands are tight, and prevent the pelvis from rolling backwards on the heads of the femora. *Abduction*, or outward movement of the thigh, is checked by the pubo-femoral band. *Adduction*, or inward movement (*e.g.* as in crossing one thigh over the other), is limited by the upper portion of the ilio-femoral band and the upper part of the capsule. *Rotation inwards* tightens the ischio-capsular band, and is therefore in a measure restrained by it. *Rotation outwards* is limited by the outer portion of the ilio-femoral band. In *circumduction*, which is combination of the movements of flexion, abduction, extension, and adduction, different parts of the capsular ligament are tightened at different stages of the movement.

The *flexor muscles*, which operate on the femur at the hip-joint, are chiefly—(1) the ilio-psoas, and (2) the pectineus; the *extensors* are—(1) the gluteus maximus, and (2) the gluteus medius; the *abductors*—(1) the upper part of the gluteus maximus, (2) the gluteus medius, (3) the gluteus minimus; the *adductors*—(1) the three adductors, (2) the pectineus, (3) the lower part of the gluteus maximus, and (4) the obturator externus; the *inward rotators*—(1) the anterior part of the gluteus medius, (2) the anterior part of the gluteus minimus, (3) the tensor

fasciæ femoris, and (4) the ilio-psoas; the *outward rotators*—(1) the two obturator muscles, (2) the gemelli, (3) the pyriformis, (4) the quadratus femoris, and (5) the gluteus maximus.

Dissection.—The hip-joint may be opened, and in doing this it is advisable to remove in the first instance the whole capsule, with the exception of the ilio-femoral band. The enormous strength of this portion of the capsule can in this way be appreciated. It is fully a quarter of an inch thick, and a strain varying from 250 lbs. to 750 lbs. is required for its rupture (Bigelow). It is very rarely torn asunder in dislocations, and consequently the surgeon is enabled in most cases to reduce the displacement by manipulation. The ilio-femoral band may now be removed.

The Cotyloid Ligament is a firm fibro-cartilaginous ring, which is fixed to the brim or margin of the acetabulum. It bridges across the notch, and thus completes the circumference of the cavity, deepens it, and at the same time narrows slightly its mouth. The cotyloid ligament fits closely upon the head of the femur, and acting like a sucker, exercises an important influence in retaining it in place. Both surfaces are covered by synovial membrane; its free margin is thin, but it is much thicker at its attachment to the acetabular brim.

The Transverse Ligament is composed of some transverse fibres which bridge across the notch in the inferior part of the acetabulum, and are attached to its margins. The more superficial of these fibres are more or less directly connected with the deep surface of the cotyloid ligament as it stretches across the notch, but they do not fill up the entire gap; a narrow interval is left between the transverse ligament and the bone for the entrance of bloodvessels and nerves into the joint.

The Ligamentum Teres, or interarticular ligament, is not round, as its name might lead one to expect, but somewhat flattened and triangular in shape. Its narrow femoral extremity is implanted into the upper margin of the pit which marks the head of the femur, whilst its

flattened acetabular end is bifid, and is fixed to the margins of the notch in the lower part of the acetabulum, and also to the transverse ligament. This attachment can be defined by removing the synovial membrane and some areolar tissue. The ligamentum teres is completely surrounded by synovial membrane, and a small artery runs along it to the head of the femur. It is difficult to understand the part which the ligamentum teres plays in the mechanism of the hip-joint. It presents very different degrees of strength in different individuals. It becomes very tense when the thigh is slightly flexed, adducted, and rotated outwards.

Synovial Membrane and Interior of the Joint.—A mass of soft fat occupies the non-articular bottom of the acetabular cavity. Upon this the ligamentum teres is placed, and bloodvessels and nerves enter it by passing through the notch under cover of the transverse ligament. The vessels come from the internal circumflex and the obturator arteries, and the nerves come from the anterior division of the obturator nerve and from the accessory obturator, when it is present. A nerve-twig is also supplied to the back of the joint by the nerve to the quadratus femoris.

The synovial membrane lines the interior of the capsule. From this it is reflected on to the neck of the femur, and it clothes the bone as far as the margin of the articular cartilage which covers the head. Along the line of reflection some fibres of the capsular ligament proceed upwards on the neck of the femur and raise the synovial membrane in the form of ridges. These fibres are termed *retinacula*.* At the acetabular attachment of the capsular

*These ligaments (cervical ligaments of Stanley) are of considerable surgical importance, as in intracapsular fracture of the neck of the femur they may escape rupture, and they then form a sort of natural splint which retains the fragments in apposition. Hence examinations of this class of fracture must be gently conducted, lest by rupturing this ligamentous connection, the fragments be permanently displaced.

ligament the synovial membrane is reflected on to the cotyloid ligament and invests both its surfaces. It also covers the articular surface of the transverse ligament and the cushion of fat which occupies the bottom of the cavity. Lastly, it gives a tubular investment to the ligamentum teres.

Removal of the Limb.—The limb may now be removed from the trunk by dividing the ligamentum teres. It should be taken to one of the tables set aside for the dissection of separate parts. Before proceeding to the dissection of the leg it is advisable to study the attachments of the various muscles to the femur. The bulk of these may then be removed, but a small portion of each should be left, so that their connections may again be revised, should it be found necessary to do so at a later period.

THE LEG.

Surface Anatomy.—The relation of the tibia and fibula to the surface should be carefully investigated. The sharp anterior border of the tibia or shin does not form a projection visible to the eye, but nevertheless it is subcutaneous, and can be very distinctly felt when the finger is passed along it. It pursues a slightly sinuous course, and in its lower part becomes rounded-off and indistinct. The broad flat internal surface of the shaft of the tibia is also subcutaneous below the level of the insertion of the sartorius, and the inner border of the bone can be followed very readily throughout its entire length. The fibula is more deeply placed, and the upper half of its shaft cannot be felt from the surface owing to the manner in which it is surrounded by muscles. The head of the bone, however, is very evident where it articulates the outer and back part of the tuberosity of the tibia; and for a short distance above the external malleolus the shaft of the fibula is subcu-

taneous over a triangular area which is interposed between the peroneus tertius muscle in front and the peroneus longus and brevis muscles behind.

The two malleoli form a marked projection on either side of the ankle. The internal malleolus is the broader and more prominent of the two; it does not descend so low down, however, and when viewed from the front it is observed to reach further forwards. This latter appearance is due to its greater breadth, because when examined from behind the posterior borders of the two projections are seen to occupy very much the same plane.

On the posterior aspect of the leg the prominence known as the 'calf of the leg' is visible. This is largely due to the fleshy bellies of the gastrocnemius muscle. Below the calf and immediately above the heel the powerful tendo Achillis can be felt. On either side and in front of this tendon a slight hollow is visible.

As the skin is reflected from the dorsum of the foot during the dissection of the leg, the present opportunity should be seized for studying the surface anatomy of the foot. The individual tarsal bones cannot be recognized through the integuments which cover the dorsum of the foot; but if the foot be powerfully extended the head of the astragalus will be brought into view in the shape of a slight prominence. The margins of the foot require very careful study, because it is by the recognition of certain bony projections in these that the surgeon is enabled to determine the point at which to enter the knife when he is called upon to perform partial amputation of the foot. Examine the inner margin first. Begin behind at the projection formed by the internal tuberosity of the os calcis, and proceed forwards. About one inch below the internal malleolus the inner edge of the sustentaculum tali may be recognized, and about one inch or a little more in front of this we recognize the tubercle of the scaphoid. Then comes the internal cuneiform bone, and this is succeeded by the first metatarsal bone. None of these bony points

can be said to form distinct prominences on the surface of a well-developed foot. In order to distinguish them the inner margin of the foot must be judiciously manipulated by the fingers. On the outer margin of the foot the tubercle on the base of the fifth metatarsal bone stands out as a distinct landmark. Behind this is the cuboid, and still further back the outer surface of the os calcis, which is almost completely subcutaneous. When present in a well-developed form the peroneal tubercle on this surface may be distinguished about one inch below and a little in front of the external malleolus. If the foot be strongly inverted the anterior end of the os calcis will be seen to project on the surface.

Subdivision of the Leg into Regions.—In the dissection of the leg four distinct regions may be recognized, viz. :—

1. *An anterior tibio-fibular region*, in which are placed those structures which lie in front of the interosseous membrane, and between the two bones of the leg.
2. *A tibial region*, corresponding to the subcutaneous or inner surface of the shaft of the tibia.
3. *A peroneal region*, which includes the parts in relation to the outer surface of the fibula.
4. *A posterior tibio-fibular region*, in which are placed the parts on the back of the leg which lie behind the interosseous membrane and the two bones of the leg.

ANTERIOR TIBIO-FIBULAR REGION—DORSUM OF FOOT.

The anterior tibio-fibular region should be dissected first, and it is usual to conjoin with this the dissection of the dorsum of the foot. The following parts are exposed in this region :—

1. Superficial veins.
2. Cutaneous nerves.
3. Deep fascia, its intermuscular septa, and annular ligaments.
4. Tibialis anticus.
5. Extensor longus digitorum.
6. Peroneus tertius.
7. Extensor longus hallucis.
8. Anterior tibial vessels.
9. Anterior peroneal artery.
10. Anterior tibial nerve.
11. Recurrent articular branch from the external popliteal nerve.
12. Extensor brevis digitorum.
13. Dorsalis pedis artery.

To place the limb in a convenient position for the dissection of this region a block should be introduced beneath the knee, and the foot should be extended and fastened firmly to the table by means of hooks.

Reflection of Skin.—The skin should be reflected from the *tibial* and *peroneal* regions at the same time. *Incisions*:—(1) a vertical cut along the middle line of the leg and dorsum of the foot to the base of the middle toe; (2) a transverse incision across the ankle-joint; (3) a transverse incision across the dorsum of the foot at the roots of the toes.

The four flaps of skin thus mapped out must now be raised from the subjacent fatty tissue, and the superficial veins and nerves dissected out.

Superficial Veins.—The *venous arch* on the dorsum of the foot, which receives the digital veins, should in the first place be dissected. From the inner extremity of this arch the *internal saphenous vein* will be seen to take origin,

whilst from its outer end the *external saphenous vein* proceeds. Trace these vessels upwards. The former will be found to pass *in front* of the internal malleolus, whilst the latter ascends *behind* the external malleolus. Each is associated with the nerve which bears its own name.

Cutaneous Nerves.—The following are the cutaneous nerves which must be secured in this dissection:—

1. A branch from the external popliteal.
2. External saphenous.
3. Internal saphenous.
4. Musculo-cutaneous.
5. Anterior tibial.

The branch from the *external popliteal* frequently arises in common with the ramus communicans fibularis. It turns forwards, and is distributed upon the outer and anterior aspect of the leg in its upper part. The *external saphenous nerve* can be readily found. It reaches the outer margin of the foot by passing behind the external malleolus in company with the vein of the same name. Trace it forwards, and it will be found to end upon the fibular side of the little toe. On the dorsum of the foot a connecting twig passes between the external saphenous and the outer division of the musculo-cutaneous. The *internal* or *long saphenous nerve* should be looked for in front of the inner malleolus. It descends in company with the internal saphenous vein. It can with care be followed half-way along the inner margin of the foot, but then it ends. Above the ankle-joint several minute twigs from this nerve may be found passing forwards to reach the front of the leg.

The *cutaneous portion* of the *musculo-cutaneous nerve* appears in the lower third of the leg. It pierces the deep fascia a short way to the outside of the middle line of the limb. Almost immediately it splits into an inner and an outer part. The *inner division* should be traced first. It extends forwards on the dorsum of the foot, and sends

one branch to the inner side of the great toe, and a second to supply the adjacent sides of the second and third toes. It likewise gives a number of twigs to the skin upon the inner margin of the foot, and effects a junction with the anterior tibial and internal saphenous nerves. The *outer division* is smaller than the inner part. It gives several twigs to the skin on the dorsum of the foot, communicates with the external saphenous nerve, and then divides into two branches, which supply the contiguous margins of the third, fourth, and fifth toes. With the exception of the adjacent sides of the great toe and the second toe, which are supplied by the anterior tibial nerve, and the outer side of the little toe, which is supplied by the external saphenous nerve, the musculo-cutaneous, therefore, furnishes twigs to the two margins of each of the other toes.*

The *anterior tibial nerve*, or rather its *internal terminal branch*, pierces the deep fascia on the dorsum of the foot in the interval between the first and second metatarsal bones. It receives a communicating branch from the inner part of the musculo-cutaneous, and ends by dividing into two twigs, which go to supply the adjacent margins of the great toe and the second toe.

Deep Fascia.—The fatty superficial fascia should be removed in order that the deep fascia may be displayed. This aponeurosis does not form a complete investment for the leg. It is absent over the internal subcutaneous surface of the tibia, and is attached to the anterior and internal borders of that bone. It is also absent over the triangular subcutaneous surface on the lower part of the fibula, being attached to the ridges which limit this area

* The above is the generally accepted description of the distribution of the musculo-cutaneous nerve on the dorsum of the foot. Very frequently, however, it is much more restricted, and in these cases the external saphenous nerve will in all probability be found to supply the outer two and a half toes.

in front and behind. It is not equally dense throughout. In the upper part of the front of the leg it is thick and strong, but it thins as it is traced downwards, and on the dorsum of the foot it becomes exceedingly fine. Its great strength in the upper part of the front of the leg is due to the fact that here it gives origin to subjacent muscles. In the neighbourhood of the ankle-joint it forms the thickened bands or annular ligaments which retain the tendons in position during the action of the muscles. Two of these may be examined at this stage, viz. the anterior and the external annular ligaments.

The *anterior annular ligament* consists of two portions—an upper and a lower. The *upper part* is a strong, broad band which stretches across the front of the leg immediately above the ankle-joint. By one extremity it is attached to the fibula, and by the other to the tibia. The *lower part* is placed over the ankle-joint. Externally it presents the appearance of a narrow, well-defined band, which is fixed firmly to the anterior part of the os calcis. As this is traced inwards it will be observed to divide into two diverging limbs. Of these the upper is attached to the inner malleolus, whilst the lower passes to the inner margin of the foot, and becomes connected with the plantar fascia. The different parts of the anterior annular ligament are continuous with the deep fascia, but can readily be distinguished on account of their greater density and thickness.

The *external annular ligament* is short and narrow, and bridges over the hollow between the external malleolus and the posterior prominence of the os calcis.

Intermuscular Septa.—As the deep fascia of the leg passes backwards over the fibular region, two strong intermuscular septa are given off from its deep surface. These are distinguished as the anterior and posterior peroneal septa. The *anterior peroneal septum* intervenes between the peroneal muscles and the extensor muscles, and is attached to

the anterior border of the fibula. The *posterior peroneal septum* is interposed between the peroneal muscles and the muscles on the back of the leg, and is attached to the external border of the fibula. The leg is thus subdivided into three osteo-fascial compartments, corresponding to the anterior tibio-fibular, peroneal, and posterior tibio-fibular regions. The *anterior compartment* is bounded by the investing deep fascia, the anterior peroneal septum, the anterior part of the inner surface of the fibula (that

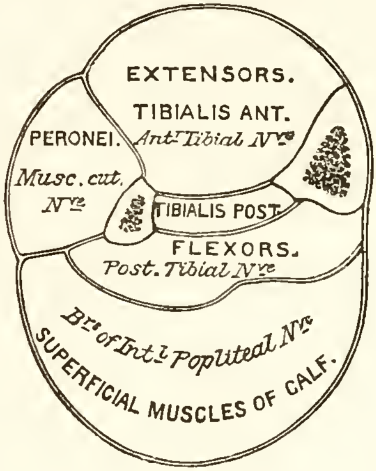

FIG. 64.

Diagrammatic representation of the fascia of the Leg. The fascia of the tibialis posticus is more a muscular aponeurosis than a true fascial septum; but it is convenient for descriptive purposes to regard it as one of the partitions.

part which lies in front of the interosseous line), the interosseous membrane, and the external surface of the tibia. The *outer compartment* is bounded by the external surface of the fibula, the investing fascia, and the two peroneal septa. The *posterior compartment* is much the largest, and its walls are formed by the posterior surface of the tibia, the hinder part of the internal surface and the whole of the posterior surface of the fibula, the interosseous membrane, the posterior peroneal septum, and the investing

deep fascia. This compartment is still further subdivided by two partitions; but these will be studied later on.

Dissection.—The anterior compartment of the leg should now be opened by removing the deep fascia. The two portions of the anterior annular ligament, however, must be retained, and their borders should be defined and separated artificially by the knife from the deep fascia, with which they are continuous. In the upper part of the leg it will be found impossible to raise the fascia from the subjacent muscles. It should therefore be left in position. At a lower level it can readily be separated. Divide it in a longitudinal direction midway between the tibia and fibula. On throwing the inner piece inwards, its firm attachment to the anterior border of the tibia will become evident; and as the outer piece is turned outwards, the anterior peroneal septum will come into view.

Contents of the Anterior Tibio-fibular Compartment.—Four muscles are brought into view by the above dissection, viz. the tibialis anticus, the extensor longus digitorum, the extensor longus hallucis, and the peroneus tertius. The *tibialis anticus* lies in relation to the tibia; the *extensor longus digitorum* is placed along the fibula; and on separating these muscles from each other, the *extensor longus hallucis* will be observed in the interval between them. The *peroneus tertius* lies upon the lower portion of the fibula, and in most cases is incorporated with the extensor longus digitorum. The *anterior tibial vessels* and *nerve* proceed downwards in this compartment. At first they are deeply placed, but as they approach the ankle they come nearer to the surface. To expose them in their entire course on the front of the leg, the tibialis anticus and the extensor longus digitorum must be separated from each other along the line of a strong intermuscular septum, which dips backwards between them, and affords a surface of origin to each. The knife should be carried upwards along the plane of this septum. By

drawing aside the peroneus tertius muscle, the *anterior peroneal artery* will be seen piercing the interosseous membrane. It is a small artery which descends upon the lower end of the fibula.

Dissection.—As the structures in the anterior tibio-fibular compartment are being exposed and cleaned, the dissector should at the same time carry on the dissection of the dorsum of the foot. Here the tendons of the muscles on the front of the leg must be followed to their insertions, and the *extensor brevis digitorum muscle* defined. The *dorsalis pedis artery* and the *anterior tibial nerve* should also be followed, and their branches traced to their various destinations.

The Tibialis Anticus is a powerful muscle, which takes origin from the lower part of the external tuberosity of the tibia, and from the upper half of the external surface of its shaft. It likewise derives many fibres from the deep fascia which covers it, from the fascial septum between it and the extensor longus digitorum and the portion of the interosseous membrane on which it rests. In other words, it springs from the structures which form the walls of the inner portion of the osteo-fascial compartment in which it lies.* A strong tendon issues from its fleshy belly in the lower third of the leg, and this reaches the dorsum of the foot by passing through both portions of the anterior annular ligament. Here it inclines inwards, and turning round the inner margin of the foot gains insertion by two slips into the inner and lower part of the internal cunei-

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* To understand the attachments of the muscles of the leg it is necessary to bear in mind that the interosseous membrane, which stretches across the interval between the two bones of the leg, and thus extends the surface of origin for these muscles, is attached to the *outer* border of the tibia (*i. e.* between its outer and posterior surfaces) and to the interosseous line of the fibula. This interosseous line traverses the inner surface of the fibula, so as to divide it into an anterior and a posterior part. The anterior part gives origin to the extensor muscles and the posterior part to the flexor muscles.

form bone, and into the adjoining part of the base of the first metatarsal bone. The tibialis anticus is supplied by the anterior tibial nerve.

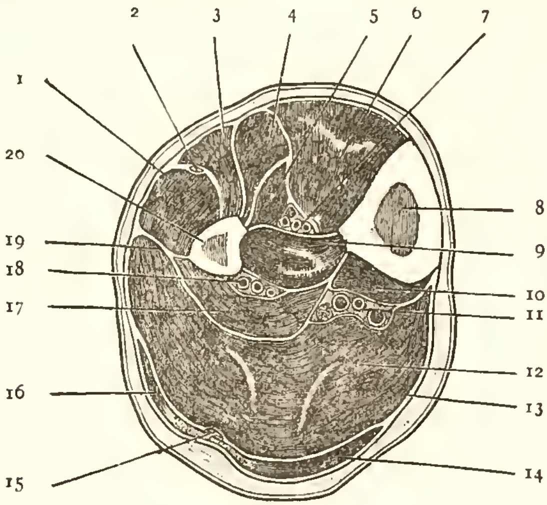

FIG. 65.

Transverse section through the Calf of the Leg.

1. Peroneus longus.
2. Musculo-cutaneous nerve.
3. Peroneus brevis,
4. Extensor longus digitorum.
5. Extensor longus hallucis.
6. Tibialis anticus.
7. Anterior tibial vessels and nerve.
8. Tibia.
9. Tibialis posticus.
10. Flexor longus digitorum.
11. Posterior tibial vessels and nerve.
12. Soleus.
13. Investing fascia
14. Gastrocnemius (inner head).
15. Plantaris.
16. Gastrocnemius (outer head).
17. Flexor longus hallucis.
18. Peroneal vessels.
19. Posterior peroneal septum.
20. Fibula.

The Extensor Longus Digitorum arises, for the most part, from the structures which form the outer portion of the wall of the anterior tibio-fibular compartment. Thus it springs from the upper part of the outer tuberosity of the tibia, from the head of the fibula, and from the anterior part of the inner surface of the shaft of the fibula in its upper three-fourths. It also takes origin from a small portion of the upper part of the interosseous membrane, the deep fascia, the anterior peroneal septum, and the

intermuscular septum, which dips backwards between it and the tibialis anticus. The tendon of the extensor longus digitorum descends in front of the ankle-joint, and passing through the anterior annular ligament divides into four pieces, which diverge from each other on the dorsum of the foot to reach the four outer toes. On the dorsum of the first phalanx each of the inner three slips is joined on the outer side by a tendon from the extensor brevis digitorum.

The manner in which the four tendons of the extensor longus digitorum are inserted on the dorsal surfaces of the four outer toes is so similar to that in which the corresponding tendons of the fingers are attached, that a very brief description will suffice. An expansion is formed on the dorsal surface of the first phalanx; this is joined by the slender tendons of the lumbrical and interosseous muscles, and divides into a central and two lateral slips. The central slip is inserted into the base of the second phalanx, whilst the stronger lateral slips are prolonged onwards, and, uniting with each other, gain insertion into the base of the ungual phalanx.

The Extensor Longus Hallucis is placed in the interval between the tibialis anticus and the extensor longus digitorum. In its upper part it is hidden from view by these muscles, but near the ankle it comes to the surface. It takes origin behind the extensor longus digitorum, from the anterior part of the inner surface of the shaft of the fibula in its middle two-fourths, and also from the adjoining part of the interosseous membrane. Its tendon crosses the lower part of the anterior tibial artery, and reaches the dorsum of the foot by passing downwards in front of the ankle-joint and through the anterior annular ligament. It is inserted into the dorsal aspect of the base of the ungual phalanx of the great toe.* It is *not joined* by the innermost tendon of the extensor brevis digitorum.

* In most cases it gives a slip to the base of the proximal phalanx.

The Peroneus Tertius is a small muscle which is continuous at its origin with the extensor longus digitorum. It arises from the lower fourth of the anterior part of the inner surface of the fibula, and from a corresponding extent of the interosseous membrane. It also receives fibres from the lower part of the anterior peroneal septum which intervenes between it and the peroneus brevis. Its slender tendon is inserted into the dorsal surface of the expanded base of the fifth metatarsal bone. It is supplied by the anterior tibial nerve.

Anterior Tibial Artery.—The anterior tibial artery is the smaller of the two terminal branches of the popliteal. It takes origin on the back of the leg, at the lower border of the popliteus muscle, and it gains the anterior tibio-fibular compartment by passing forwards through the opening in the upper part of the interosseous membrane. In this part of its course it lies close to the inner side of the neck of the fibula, and appears in the present dissection immediately below the outer tuberosity of the tibia. On the front of the leg it takes a straight course downwards to the ankle-joint. Here it reaches the dorsum of the foot, and receives the name of *dorsalis pedis*.

In the upper two-thirds of the leg the anterior tibial artery is very deeply placed. It lies upon the interosseous membrane in the interval between the tibialis anticus on the inner side and the extensor longus digitorum and the extensor longus hallucis on the outer side. In the lower third of the leg where the muscles give place to their tendons the artery comes nearer to the surface. In this part of its course it rests upon the tibia and is overlapped on the outer side by the extensor longus hallucis. Immediately above the ankle-joint the tendon of that muscle crosses the artery and comes to lie on its inner side.

Two *venae comites* closely accompany the anterior tibial artery, and send short communicating branches both in front of it and behind it. The *anterior tibial nerve* is also

intimately related to it. It joins the artery a short distance below the knee and soon takes up a position in front of the vessel. Near the ankle-joint the nerve as a rule assumes a place on the outer side of the artery.

On the front of the leg the anterior tibial artery gives off the following branches:—

1. Muscular.
2. Anterior tibial recurrent.
3. External malleolar.
4. Internal malleolar.

The *muscular branches* are very numerous and come off at irregular points along the whole length of the artery. They supply the muscles on the front of the leg, and send a few twigs forwards to reach the skin, and others backwards through the interosseous membrane to the tibialis posticus muscle.

The Recurrent Tibial Artery springs from the anterior tibial immediately after it reaches the front of the leg. It turns upwards on the external tuberosity of the tibia in the fibres of the tibialis anticus muscle. Its terminal twigs reach the front of the knee-joint, and anastomose with the inferior articular branches from the popliteal artery.

The Malleolar Arteries take origin immediately above the ankle-joint. The *external malleolar* is the larger of the two, and passes outwards under cover of the tendons of the extensor longus digitorum and peroneus tertius, to reach the outer surface of the external malleolus. It anastomoses with the anterior peroneal and tarsal arteries. The *internal malleolar* runs inwards under cover of the tendons of the extensor longus hallucis and tibialis anticus. It inosculates with branches from the posterior tibial artery.

Arteria Dorsalis Pedis.—The dorsal artery of the foot is the continuation of the anterior tibial. It begins in front of the ankle-joint at a point midway between the two malleoli, and it extends forwards upon the forepart of the astragalus, the scaphoid, and the middle cuneiform bones to the posterior part of the interosseous space between the

metatarsal bones of the great toe and the second toe. Here it leaves the dorsum of the foot by dipping downwards between the two heads of the first dorsal interosseous muscle to reach the sole and unite with the external plantar artery in the formation of the plantar arch. Its relations on the dorsum of the foot are very simple. (1). It lies in the interval between the tendon of the extensor longus hallucis on the inner side and the innermost tendon of the extensor longus digitorum on the outer side. (2.) At its commencement it is crossed by the lower part of the anterior annular ligament, whilst near its termination it is crossed by the innermost tendon of the extensor brevis digitorum ; with these exceptions the vessel is simply covered by the integument and fascia. (3.) The internal terminal branch of the anterior tibial nerve lies along its outer side, and two *venae comites* accompany it.

As the dorsalis pedis artery traverses the dorsum of the foot it gives off several twigs to the inner margin of the foot, and also three named branches :—

1. The tarsal.
2. The metatarsal.
3. The first dorsal interosseous.

Tarsal and Metatarsal Arteries.—The *tarsal artery* arises opposite the scaphoid bone, and the *metatarsal artery* near the bases of the metatarsal bones. They both run outwards under cover of the extensor brevis digitorum to reach the outer margin of the foot. There they anastomose with branches of the external plantar artery. The tarsal artery also anastomoses with the external malleolar and peroneal arteries.

From the arch which is formed by the metatarsal artery *three dorsal interosseous arteries* proceed, one to each of the three outer interosseous spaces. At the clefts between the toes these divide and supply dorsal digital twigs to the adjacent sides of the second, third, fourth, and fifth toes. From the outermost interosseous artery a twig is also given to the outer side of the little toe.

The First Dorsal Interosseous Artery takes origin from the dorsalis pedis at the point where it turns downwards to reach the sole of the foot. It continues forwards upon the first dorsal interosseous muscle, and divides into dorsal digital branches from the inner side of the great toe and the adjacent sides of the great toe and second toe.

The Anterior Peroneal Artery is one of the two terminal branches of the peroneal branch of the posterior tibial. It reaches the front of the leg by piercing the interosseous membrane about one and a-half or two inches above the outer malleolus, and it descends upon the lower part of the fibula under cover of the peroneus tertius. It is distributed on the outer side of the tarsus, where it anastomoses with the external malleolar and the tarsal arteries.

The Extensor Brevis Digitorum may now be examined. It arises from the anterior part of the os calcis, and also from the lower part of the anterior annular ligament. It splits into four fleshy bellies, which extend forwards and inwards on the dorsum of the foot, and end in four slender tendons for the four inner toes. The *innermost tendon* crosses the dorsalis pedis artery near its termination, and is inserted into the dorsal aspect of the base of the first phalanx of the great toe; the remaining three tendons join the long extensor tendons which go to the second, third, and fourth toes. The extensor brevis digitorum is supplied by the external branch of the anterior tibial nerve.

Anterior Tibial Nerve.—The anterior tibial nerve is one of the terminal branches of the external popliteal. It arises on the outer side of the neck of the fibula, and, piercing the upper part of the extensor longus digitorum obliquely, joins the anterior tibial vessels a short distance below the external tuberosity of the tibia. These it accompanies for the remainder of its course. In the first instance it is placed in front of them, but near the ankle-joint it lies on their outer side. Passing behind the ante-

rior annular ligament, it ends by dividing into an internal and an external branch.

In its course through the leg the anterior tibial nerve gives *muscular branches* to the extensor longus digitorum, tibialis anticus, the extensor longus hallucis, and the peroneus tertius; likewise a fine *articular twig* to the ankle-joint.

The *internal terminal branch* of the anterior tibial nerve is continued forwards upon the dorsum of the foot along the outer side of the dorsalis pedis artery. Reaching the first interosseous space it pierces the deep fascia, and divides to supply the contiguous margins of the great toe and the second toe (p. 371). Before it reaches the surface, it furnishes *articular twigs* to the tarso-metatarsal and metatarso-phalangeal joints of the great toe, and frequently also a fine *muscular twig* to the dorsal surface of the first dorsal interosseous muscle.

The *external terminal branch* of the anterior tibial nerve turns abruptly outwards under cover of the extensor brevis digitorum, and ends on the dorsum of the foot in a gangliform enlargement. From this branches proceed for the supply of the extensor brevis digitorum, and the numerous articulations in the neighbourhood. One fine filament can, in most cases, be traced to the second dorsal interosseous muscle. The terminal swelling resembles closely the corresponding enlargement in which the posterior interosseous nerve of the upper limb ends.

Anterior Annular Ligament.—The dissector should again examine this ligament, and the arrangement of the structures which pass under it. The *upper portion* is attached to the fibula by its outer end, and to the tibia by its inner extremity. By dividing its fibular attachment, and throwing it inwards, it will be seen to give a separate and distinct sheath to the tibialis anticus.

The *lower portion* is the more important of the two. Its attachments have already been noted (p. 372). Examine

closely the manner in which it holds the tendons in their place. It consists of two layers, and these, by separating at certain points and becoming re-united at others, form three distinct compartments. Through the *innermost* passes the tendon of the tibialis anticus; through the *middle* one passes the tendon of the extensor longus hallucis; and through the *outermost* are transmitted the tendons of the extensor longus digitorum and peroneus tertius. On opening up these sheaths each will be seen to be lined by a synovial membrane. Lastly, note the position of the anterior tibial vessels and nerve as they pass under cover of the ligament. They lie between the extensor longus hallucis and the extensor longus digitorum.

PERONEAL REGION.

The peroneal or outer compartment of the leg should now be opened by dividing, in a longitudinal direction, the fascia which covers it. Enclosed within it are :—

1. The peroneus brevis.
2. The peroneus longus.
3. The termination of the external popliteal nerve.
4. The musculo-cutaneous nerve.

The Peroneus Longus arises from the head and from the outer surface of the shaft of the fibula in its upper two-thirds. A surface of origin is also afforded to it by the fascia which covers it, and by the two peroneal intermuscular septa. It ends a short distance above the ankle in a long tendon, which is continued downwards behind the external maleolus. Gaining the outer margin of the foot, it proceeds forwards to the groove on the under surface of the cuboid, which conducts it transversely into the sole. Its insertion will be examined at a later period.

The Peroneus Brevis arises from the lower two-thirds of the outer surface of the shaft of the fibula below and

in front of the peroneus longus, and from the peroneal intermuscular septum on either side of it. Its tendon descends behind the external malleolus, and then turns forwards on the outer surface of the os calcis to gain an insertion into the projecting base of the metatarsal bone of the little toe.* On the back of the external malleolus the tendon of the peroneus brevis lies directly under cover of the tendon of the peroneus longus, and therefore in contact with the bone. On the outer surface of the os calcis the tendon of the peroneus brevis is placed at a higher level than that of its fellow muscle.

As the tendons of the two peronei muscles proceed downwards in the hollow between the external malleolus and the posterior prominence of the os calcis they are held in place by the *external annular ligament*, and their movements are facilitated by the presence of a common synovial sheath. On the outer surface of the os calcis each tendon is retained in position by a separate fibrous sheath, into which the common synovial membrane is prolonged. The peroneal tubercle of the os calcis intervenes between these two sheaths.

External Popliteal Nerve.—This nerve has previously been traced as far as the neck of the fibula. At this point it disappears from view by passing forwards between the peroneus longus muscle and the bone. The muscle must therefore be carefully turned aside from its origin in order that the nerve may be followed out. It will be found to give off a small *recurrent articular nerve* to the knee-joint, and then to divide into the *anterior tibial* and *musculo-cutaneous nerves*.

The *recurrent* branch accompanies the anterior recurrent tibial artery. It turns upwards in the fibres of the tibialis

*A small tendinous slip will, as a general rule, be observed to proceed forwards from the tendon of the peroneus brevis to join the tendon of the long extensor on the dorsum of the little toe. This is the *peroneus quinti digiti*.

anticus. To the upper part of this muscle it gives several twigs, whilst its terminal filaments gain the front of the knee-joint.

The *anterior tibial nerve* pierces the upper part of the extensor longus digitorum to reach the front of the leg, where it has already been dissected.

The Musculo-cutaneous Nerve proceeds downwards in the substance of the peroneus longus. It reaches the interval between the two peronei muscles, gives branches to both, and lastly comes to lie between the peroneus brevis and the extensor longus digitorum. In the lower third of the leg it pierces the fascia, and becomes cutaneous.

TIBIAL REGION.

This region corresponds to the subcutaneous or inner surface of the tibia. The deep fascia blends with the periosteum of the bone, and the only structures which have to be examined are:—

1. The internal saphenous vein.
2. The internal saphenous nerve.
3. The expanded tendons of insertion of the sartorius, semitendinosus, and gracilis.
4. Internal lateral ligament of the knee-joint.
5. Inferior internal articular artery and nerve.

The internal saphenous nerve and vein, as they pass from the anterior to the posterior tibio-fibular region, cross obliquely over the lower third of the inner surface of the tibia.

The insertion of the *sartorius*, *gracilis*, and *semitendinosus* into the upper part of the inner surface of the tibia should again be examined. Observe how the sartorius overlaps the tendons of the other two, and how the tendon of the gracilis overlaps the upper part of the tendon of the semitendinosus. A synovial bursa separates these tendons from each other.

The *internal lateral ligament* of the knee-joint will be seen extending downwards for a short distance upon the inner aspect of the shaft of the tibia. Passing forwards under cover of this ligament, so as to gain the anterior aspect of the knee, are the *inferior internal articular vessels* and *nerve.*

POSTERIOR TIBIO-FIBULAR REGION.

The limb must now be placed on its anterior aspect, and the muscles of the calf rendered tense by flexing the foot at the ankle-joint. This position should be maintained by the aid of hooks, fastened on the one hand to the toes and on the other hand to the under surface of the table.

The following is a list of the structures which are met with in this dissection :—

1. Superficial veins, { Internal saphenous. External saphenous.
2. Cutaneous nerves.
3. Deep fascia.
4. Superficial muscles of the calf, { Gastrocnemius. Plantaris. Soleus.
5. Tendo Achillis and its bursa.
6. Posterior tibial vessels.
7. Posterior tibial nerve.
8. Deep muscles. { Popliteus. Flexor longus hallucis. Tibialis posticus. Flexor longus digitorum.
9. Internal annular ligament.

Reflection of Skin.—*Incisions.*—(1) A longitudinal incision along the middle line of the leg on its posterior aspect to the extremity of the heel. (2) A transverse incision at the lower end of this, extending along the inner and outer margins of the foot for about two inches on either side.

The two flaps of skin thus marked out must be raised and turned outwards and inwards.

Superficial Veins.—The *internal* and *external saphenous* veins must be traced in the substance of the fatty superficial fascia. Both of these vessels have been seen in previous steps of the dissection. The *internal saphenous vein* has been observed to arise from the inner extremity of the venous arch on the dorsum of the foot, and it has been followed upwards for a short distance in front of the inner malleolus, and then upon the inner aspect of the lower part of the tibia. It has also been dissected upon the inner aspect of the thigh and knee. It can now be exposed in its course along the inner side of the calf of the leg. It lies a short distance behind the internal border of the tibia. The *external saphenous vein* has been seen to arise from the outer end of the dorsal arch and to pass upwards behind the outer malleolus. It may now be followed as it ascends along the outer side of the tendo Achillis to the back of the leg, where it lies over the interval between the two heads of the gastrocnemius muscle. When it gains the lower part of the popliteal space it pierces the deep fascia and joins the popliteal vein.

Associated with each of these veins are certain cutaneous nerves, which must be displayed at the same time. The *small sciatic* is closely related to the external saphenous vein in its upper part, and the *external saphenous nerve* accompanies it in the lower half of the leg. In company with the *internal saphenous vein* we find the *internal* or *long saphenous nerve.*

Cutaneous Nerves.—These are very numerous. On the *inner side* of the leg are—(1) the *internal* or *long saphenous;* (2) the *posterior branch* of the *internal cutaneous;* and (3) the *internal calcanean.*

The guide to the *internal saphenous* nerve is the vein of the same name. It may now be exposed in its entire

course along the inner side of the leg. The *posterior branch* of the *internal cutaneous* proceeds downwards a short distance behind the preceding nerve. It usually ends about the middle of the leg. The *internal calcanean* is a branch of the posterior tibial nerve. Dissect for it in the interval between the prominence of the heel and internal malleolus. It pierces the internal annular ligament nearer the former than the latter. Its distribution to the skin of the heel and sole will be seen in a future dissection.

In the *middle line* of the leg two nerves will be found, viz.—(1) the *small sciatic*, and (2) the *nervus communicans tibialis*. They have both been previously seen in the dissection of the popliteal space. The *nervus communicans tibialis*, a branch of the internal popliteal, descends in the interval between the two heads of the gastrocnemius and pierces the deep fascia midway between the knee and ankle. A short distance below this it is joined by the nervus communicans fibularis, and then acquires the name of *external saphenous*.

On the *outer side* of the posterior aspect of the leg is the *nervus communicans fibularis*, a branch of the external popliteal. It descends upon the outer head of the gastrocnemius, and, perforating the deep fascia, unites with the nervus communicans tibialis a short distance below the middle of the leg, to form the *external saphenous nerve*. The latter has already been traced behind the external malleolus to the outer margin of the foot and little toe.

Deep Fascia.—A continuous view of the deep fascia on the back of the leg can now be obtained by removing the remains of the superficial fat. Observe how thin and transparent it is in the upper part of the leg, and how it thickens as it is followed downwards towards the heel. At no point, however, is it very dense. As it passes over the interval between the heel and the internal malleolus it forms the *internal annular ligament*. It is continuous

above with the popliteal fascia, and a short distance below the knee, on the inner side, it receives a reinforcement of fibres from the tendons of the sartorius, the gracilis, and the semitendinosus. Divide the fascia along the middle line and turn it outwards and inwards. Leave the internal annular ligament intact. On raising the inner part of the fascia it will be seen to be attached to the internal border of the tibia. In fact, it blends with the periosteum covering the inner subcutaneous surface of this bone. On turning the outer portion of fascia outwards it will be observed to be directly continuous with the fascia on the front of the leg: further, the strong intermuscular septum (posterior peroneal septum) which passes in to join the external border of the fibula between the peroneal muscles and the muscles on the posterior aspect of the leg will be demonstrated. In this manner, then, the large posterior osteo-fascial compartment is formed, and, as the dissection goes on, two partitions will be noticed to stretch across it so as to subdivide it into three portions. The most superficial of these holds the superficial muscles of the calf; the intermediate portion contains the flexor muscles with the posterior tibial vessels and nerve; whilst the deepest part encloses the tibialis posticus muscle (Fig. 66).

One of these partitions may be exposed at the present moment by removing the fat which is usually accumulated under cover of the tendo Achillis. Subjacent to this tendon is the layer of fascia in question. It stretches between the tibia and fibula, and separates the superficial from the deep group of muscles. When the fat has been removed this fascia will be seen to be very dense, and to be strengthened by numerous transverse fibres. It becomes continuous on the inner side of the ankle with the internal annular ligament—indeed, the dissector will not fail to observe that it takes a more prominent part in the formation of this ligament than the general aponeurosis of the limb. In the upper part of the leg it is very thin.

Superficial Muscles.—The superficial muscles of the calf of the leg are three in number, viz. the gastrocnemius, the plantaris, and the soleus. The gastrocnemius is the most superficial; the soleus is placed under cover of the gastrocnemius; whilst the slender plantaris extends downwards and inwards between them. The tendons of insertion of the gastrocnemius and soleus unite to form the tendo Achillis.

The Gastrocnemius arises by two heads from the posterior aspect of the lower end of the femur. These heads have been already studied in connection with the popliteal space which they bound in its lower part. The *outer head* springs from an impression on the outer surface of the external condyle of the femur, and also from a small portion of the posterior surface of the bone immediately above the condyle. The *inner head* takes origin from the upper part of the internal condyle, and likewise from the inferior portion of the internal supracondyloid ridge of the femur. The two fleshy bellies swell out as they descend, and end near the middle of the leg in a thin aponeurotic tendon. They do not blend with each other. They are usually separated by a furrow, at the bottom of which the flattened tendon may be seen. The internal head is the more bulky of the two, and it extends lower down than the external head. The flattened tendon in which they terminate narrows slightly as it descends, and a short distance below the middle of the leg it blends with the stouter tendon of the soleus to form the tendo Achillis.

Dissection.—The aponeurotic tendon of the gastrocnemius may be divided, and the two heads of origin thrown upwards towards the back of the femur. The sural arteries from the popliteal trunk, and the branches of supply from the internal popliteal nerve which enter them, can thus be preserved. On raising the upper portion of the inner head, a bursa which intervenes

between it and the condyle of the femur will be brought into view. On opening this with the knife it will, in all probability, be found to communicate with the interior of the knee-joint. The smooth and tendinous opposed surfaces of the gastrocnemius and the soleus, and the narrow tendon of the plantaris which passes downwards and inwards between them, are displayed.

Plantaris.—The small fleshy belly of the plantaris is not more than three or four inches long. It lies along the inner side, and partly under cover of the outer head of the gastrocnemius, and it arises from the posterior surface of the femur immediately above its external condyle. It ends in a slender tendon which is remarkable for its great length. This proceeds downwards and inwards, and then runs along the inner side of the tendo Achillis to gain insertion into the posterior aspect of the os calcis. It is frequently closely connected with the tendo Achillis, and sometimes becomes blended with it or with the fascia of the leg before it reaches the os calcis.

The plantaris is supplied by a branch from the internal popliteal nerve. It may now be reflected.

The Soleus is a flat, thick, and powerful muscle which arises from both bones of the leg, as well as from a strong fibrous arch which is thrown across the posterior tibial vessels. Its *fibular origin* is from the posterior surface of the head and the upper third of the posterior surface of the shaft of the bone: by its *tibial origin* it is attached to the oblique line below the popliteal surface, and to the internal border of the bone below this as far down as the middle of the leg. The soleus ends in a strong stout tendon which joins with the tendon of the gastrocnemius to form the tendo Achillis. Branches from the internal popliteal nerve supply the soleus.

The Tendo Achillis is the most powerful tendon in the body. It narrows as it descends, but near the heel it

again expands slightly. It is inserted into the middle portion of the posterior surface of the os calcis. The fleshy fibres of the soleus are continued downwards on its deep surface to within a short distance of the heel. A synovial bursa intervenes between the tendo Achillis and the upper part of the posterior surface of the os calcis.

Dissection.—Divide the soleus muscle transversely at the level at which it is joined by the gastrocnemius tendon, and turn downwards the tendo Achillis. Next make a vertical incision through the substance of the soleus in the middle line, so as to divide it into two lateral portions. By this dissection the tendinous arch which is thrown across the blood-vessels is exposed in the upper part, and both the tibial and fibular origins with the blood-vessels and nerves which enter them preserved. The two portions of the fleshy belly of the muscle may now be turned outwards and inwards, and the branches which the muscle receives from the peroneal and posterior tibial arteries may be cleaned.

The deep fascial septum which stretches across from the tibia to the fibula between the superficial and deep muscles on the back of the leg may now be removed. In doing this note the manner in which it becomes continuous below with the internal annular ligament. On no account interfere with this ligament. The posterior tibial vessels and nerve, with their branches, should be dissected with as little disturbance to the deep muscles as possible. The muscle which lies on the fibula is the flexor longus hallucis; the muscle on the tibia is the flexor longus digitorum; whilst the third muscle between and on a deeper plane than the other two is the tibialis posticus.

Termination of the Popliteal Artery.—The termination of the popliteal artery lies under cover of the upper border of the soleus. It should now be cleaned, and it will be seen to end at the lower margin of the popliteus muscle by dividing into the *anterior* and *posterior tibial arteries.*

Further, the venæ comites which accompany these vessels will be observed to join at this point to form the large popliteal vein.

The Anterior Tibial Artery passes forwards between the two heads of the tibialis posticus muscle to the front of the leg, where it has already been dissected. In this part of its course the anterior tibial artery gives off the posterior recurrent tibial and the superior fibular branch. The *posterior recurrent tibial* is a small twig which is not always present. It runs upwards under cover of the popliteus muscle to the back of the knee-joint. The *superior fibular* runs outwards on the neck of the fibula, and is distributed to the muscles and integument in the neighbourhood.

The Posterior Tibial Artery is the larger of the two terminal branches of the popliteal trunk. It takes origin at the lower border of the popliteus muscle and ends in the hollow on the inner side of the os calcis, under cover of the abductor hallucis, and at the level of the lower border of the internal annular ligament, by dividing into the external and internal plantar arteries. In the first instance the artery is placed between the two bones of the leg upon the tibialis posticus muscle; but as it descends it inclines gradually inwards, and at its termination it lies midway between the prominence of the os calcis and the internal malleolus.

In its upper two-thirds the posterior tibial artery is situated very deeply, being covered by the superficial muscles of the calf. In the lower third of the leg it appears between the tendo Achillis and the inner border of the tibia, and is merely covered by the integument, two layers of fascia, and lower down by the internal annular ligament. From above downwards it rests upon the tibialis posticus, the flexor longus digitorum, the tibia, and the posterior aspect of the ankle-joint.

Throughout its entire course the posterior tibial artery is closely accompanied by two *venæ comites*. The *posterior*

tibial nerve is at first on its inner side, but it soon crosses it, and is then continued down on its outer side.

The following are the branches which issue from the posterior tibial artery:—

1. Muscular.	4. Cutaneous.
2. Nutrient.	5. Internal calcanean.
3. Peroneal.	6. Communicating.

The *muscular branches* supply the deep muscles on the back of the leg, and one or two of large size enter the soleus.

The *cutaneous branches* are given to the skin on the inner aspect of the leg.

The *nutrient artery* springs from the posterior tibial close to its commencement, and after giving some twigs to muscles enters the nutrient foramen of the tibia. It is remarkable on account of its large size.

The *communicating branch* is given off about an inch above the lower end of the tibia. It passes transversely outwards under cover of the flexor longus hallucis, and joins the peroneal artery.

The *internal calcanean branch* pierces the internal annular ligament, and accompanies the nerve of the same name to the skin of the heel and the sole.

The *peroneal artery* is a large branch which proceeds from the posterior tibial about one inch below the lower margin of the popliteus muscle. In the present stage of the dissection it is seen running obliquely downwards and outwards upon the tibialis posticus to reach the fibula. It is covered by the soleus, and is accompanied by the nerve to the flexor longus hallucis. It cannot be traced further at present, as it sinks into the substance of that muscle.

Posterior Tibial Nerve.—This is the continuation into the back of the leg of the internal popliteal nerve. It begins at the lower border of the popliteus muscle and ends in the hollow between the heel and the internal malleolus by dividing into the external and internal plantar

nerves. It accompanies the posterior tibial vessels, and presents the same relations. For a short distance in the upper part of the leg it lies on the inner side of the posterior tibial artery, but it soon crosses it, and is then continued downwards for the remainder of its course on the outer side of the vessel.

It supplies—(*a*) *muscular branches* to the tibialis posticus, flexor longus hallucis, and flexor longus digitorum; (*b*) a *cutaneous* twig, the *internal calcanean*, which springs from it close to its termination, and pierces the internal annular ligament to reach the integument of the heel and sole of the foot; and (*c*) *articular filaments* to the ankle-joint.

Deep Muscles.—The *popliteus* muscle will be seen lying upon the posterior aspect of the knee-joint and upon the posterior surface of the tibia above the oblique line. Its tendon of origin lies within the capsule of the knee-joint, and can only be properly studied when this articulation is dissected. Note the strong fascia which covers the posterior surface of the popliteus, and trace it upwards and inwards to the inner side of the knee. Here it will be observed to be continuous with the tendon of the semimembranosus, and through it, therefore, the semimembranosus may be regarded as having an insertion into the oblique line of the tibia. The *flexor longus hallucis* is placed upon the posterior aspect of the fibula, and its tendon will be noticed to groove deeply the posterior border of the astragalus as it passes forwards to gain the sole of the foot. The *flexor longus digitorum* lies upon the tibia. The *tibialis posticus* rests upon the interosseous membrane upon a deeper plane and between the fleshy bellies of the two flexors.

The Aponeurosis covering the Tibialis Posticus is the second partition which crosses the posterior osteofascial compartment of the leg (p. 373.) It is a strong aponeurosis, which is attached on the one hand to the internal border of the fibula, and on the other to the ver-

tical ridge which descends from the oblique line on the posterior surface of the tibia. To demonstrate these attachments, the flexor muscle of the toes must be pushed inwards and some of its fibres divided. The flexor longus hallucis must in like manner be pushed outwards. The aponeurosis will then be seen to serve as a surface of origin for both of these muscles; and on its removal, it will also be observed to give fibres by its deep surface to the subjacent tibialis posticus.

The Popliteus arises by a stout narrow tendon, within the capsule of the knee-joint, from the front of the popliteal groove on the outer surface of the external condyle of the femur. The fleshy fibres are directed inwards and downwards, and spread out to obtain insertion into the posterior surface of the tibia above the oblique line, and also into the aponeurosis which covers the muscle.

The nerve to the popliteus has already been seen to arise from the internal popliteal trunk. It can now be seen hooking round the lower margin of the muscle to reach its deep surface.

The Flexor Longus Hallucis is a powerful muscle which arises from the posterior surface of the fibula below the origin of the soleus, from the posterior peroneal septum, and from the surface of the aponeurosis covering the tibialis posticus. Its tendon occupies a deep groove on the posterior border of the astragalus, and turns forwards under cover of the internal annular ligament to gain the sole of the foot.

The Flexor Longus Digitorum arises from the posterior surface of the tibia below the popliteus, and internal to the vertical ridge, which descends from the oblique line. It also derives fibres from the surface of the aponeurosis which covers the tibialis posticus. Crossing the lower part of the tibialis posticus, its tendon grooves the back of the internal malleolus on the outer side of the tendon of that

muscle. It is continued under cover of the internal annular ligament into the sole of the foot.

The Tibialis Posticus takes origin from the posterior surface of the interosseous membrane, from the posterior part of the inner surface of the fibula, from the posterior surface of the tibia on the outer side of the flexor longus digitorum, and from the aponeurosis which covers it. In figure 66 the compartment which it occupies is shown in a diagrammatic manner, and the surfaces from which it takes origin are

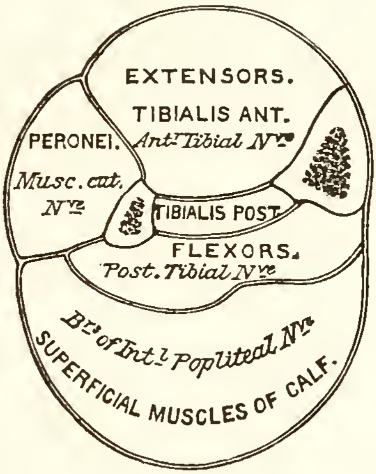

FIG. 66.

Diagrammatic representation of the fascia of the Leg. The fascia of the tibialis posticus is more a muscular aponeurosis than a true fascial septum; but it is convenient for descriptive purposes to regard it as one of the partitions.

indicated. Towards the lower part of the leg the tibialis posticus inclines inwards under cover of the flexor longus digitorum, and its strong flattened tendon grooves the back of the internal malleolus to the inner side of the tendon of that muscle. Continued under cover of the annular ligament, its tendon is inserted into the tubercle of the scaphoid, and also by a number of slips into certain of the tarsal and metatarsal bones. These will be dissected later on.

Peroneal Artery.—This vessel may now be traced downwards as it runs along the fibula under cover of the flexor longus hallucis. It is accompanied by two *venæ comites.* About an inch or an inch and a-half above the ankle-joint it ends by dividing into its two terminal branches—the anterior and the posterior peroneal arteries.

In addition to these it gives off—

1. Muscular branches.
2. The nutrient artery to the fibula.
3. The communicating artery.

The *muscular branches* supply the muscles around it. The *nutrient artery* enters the nutrient foramen on the posterior surface of the fibula. The *communicating artery* arises a short distance above the ankle-joint, and runs transversely inwards under cover of the flexor longus hallucis to join the posterior tibial artery.

The *anterior peroneal artery* passes forwards through the interosseous membrane, and has already been dissected on the front of the leg.

The *posterior peroneal artery* is continued downwards behind the external malleolus, and ends on the outer surface of the os calcis, where it anastomoses with the external malleolar, tarsal, and anterior peroneal vessels.

Internal Annular Ligament.—The connections of this thickened band of deep fascia should be carefully studied, and also the arrangement of the structures which pass under cover of it into the sole of the foot. It bridges across the hollow between the prominence of the os calcis and the internal malleolus, and it is attached to both. Above it is chiefly connected with that layer of the deep fascia which intervenes between the superficial and deep muscles on the back of the leg, but it is also continuous with the general aponeurotic investment of the leg. Inferiorly its lower margin gives origin to the abductor hallucis, and is connected with the inner portion of the plantar fascia.

Passing under cover of this ligament the dissector will observe—(*a*) the posterior tibial vessels and nerve; (*b*) to the outer side of these, the tendon of the flexor longus hallucis; (*c*) to their inner side, the tendons of the flexor longus digitorum and tibialis posticus. From within outwards these structures lie in the following order:

1. Tendon of tibialis posticus.
2. Tendon of flexor longus digitorum.
3. Posterior tibial vessels.
4. Posterior tibial nerve.
5. Tendon of flexor longus hallucis.

The tendons are isolated from each other and from the vessels and nerve by septa, which pass from the deep surface of the ligament to ridges on the bones. These septa can be demonstrated by slitting up the ligament, for a short distance, in the line of each of the tendons: each of the three sheaths will then be seen to be lined by a glistening synovial membrane.

Anastomosis around the Ankle-joint.—The dissector should next satisfy himself with regard to the anastomosis of arteries which takes place around the ankle-joint. On the *outer aspect* of the joint he will observe inosculations taking place between branches of the following arteries:—(*a*) external malleolar; (*b*) anterior peroneal; (*c*) posterior peroneal; and (*d*) tarsal.

On the *inner aspect* of the joint the internal malleolar branch of the anterior tibial anastomoses with small twigs from the internal calcanean branch of the posterior tibial.

SOLE OF THE FOOT.

In this dissection the dissector will meet with the following structures:—

1. Superficial fascia and cutaneous vessels and nerves.
2. Deep plantar fascia.
3. Superficial muscles. { Abductor hallucis. Flexor brevis digitorum. Abductor minimi digiti.
4. External and internal plantar vessels.
5. External and internal plantar nerves.
6. Tendons of flexor longus hallucis and flexor longus digitorum.
7. Musculus accessorius and lumbrical muscles.
8. Flexor brevis hallucis, adductor hallucis, and transversus pedis.
9. Flexor brevis minimi digiti.
10. Plantar arch.
11. Arteria magna hallucis.
12. Tendons of peroneus longus and tibialis posticus.
13. Interosseous muscles.

The limb should be placed upon the table, with the sole of the foot facing the dissector, and the ankle supported by a good-sized block.

Reflection of Skin.—Two incisions are required—(1) a longitudinal incision along the middle line of the sole, from the heel to the root of the middle toe; (2) a transverse cut, at the digital extremity of the mesial incision, across the sole at the roots of the toes. The skin should also be reflected from the plantar surface of each of the toes. This can be done by means of a longitudinal incision along its middle line.

Superficial Fascia and Cutaneous Nerves.—When the flaps of skin which are mapped out by the above incisions are reflected, the peculiar characters of the superficial fascia will become apparent. It is tough and granular, and in many respects resembles the superficial fascia which covers the tuber ischii. Traversing it are tough

fibrous bands, which subdivide the fatty tissue into small lobules, and connect the thick skin of the sole with the plantar fascia.

The *internal calcanean nerve,* which has already been found piercing the internal annular ligament, should be traced to its distribution. It supplies the skin of the sole in the neighbourhood of the heel.

The superficial fascia may now be removed. Divide it along the middle line of the sole, and turn it outwards and inwards, cleaning at the same time the deep fascia. As the dissector approaches the outer and inner margins of the foot respectively, he will observe two furrows to extend forwards on each side of the central part of the deep fascia. Along the line of these a number of blood-vessels and some nerves will be seen to pierce the deep fascia in order to reach the skin. Towards the heads of the metatarsal bones, the digital vessels and nerves are unprotected by the deep fascia, and here the dissector must proceed cautiously. The nerves and vessels which go to the tibial side of the hallux and to the fibular side of the little toe are especially liable to injury, as they perforate the fascia further back than the others. A band of transverse fibres, which crosses the roots of the toes and lies over the digital vessels and nerves, should be noticed. It is the *superficial transverse ligament* of the toes. It is closely connected with the skin, where it forms the cutaneous webs between the toes. By forcibly separating the toes its connections will become evident. When the relations of this ligament have been studied it may be removed.

Plantar Fascia.—The plantar fascia, which is now brought into view, will be noticed to consist of three portions—(*a*) a central, and (*b*) two lateral parts. This subdivision is indicated by a difference in the density of the three parts and by two shallow furrows which traverse the foot in a longitudinal direction, one upon either side of the strong central portion of fascia. Each of the three

portions of fascia is in relation to a subjacent muscle. The *central* portion covers the flexor brevis digitorum; the *external lateral* part clothes the abductor minimi digiti; and the *internal lateral* part covers the abductor hallucis.

The central portion of the plantar fascia stands out in marked contrast to the lateral portions in point of strength and density. Observe how it expands as it passes forwards, and how it splits into five processes, which are bound together by transverse fibres, and between which the digital vessels and nerves and the lumbrical muscles appear. Trace these processes forwards. One goes to the root of each toe, and there divides into two slips, which embrace the flexor tendons and become fixed to the flexor sheaths and to the transverse metatarsal ligament. In its arrangement therefore it closely resembles the central part of the palmar fascia.

The *lateral* parts of the plantar fascia are weak in comparison with the central portion. They simply constitute aponeurotic coverings for the muscles which lie subjacent. A strong band is to be noted in connection with the *outer* part. It stretches between the prominence formed by the base of the fifth metatarsal bone and the external tuberosity of the os calcis.

In connection with the plantar fascia two *intermuscular septa* have also to be studied. These pass upwards into the sole, along the line of the longitudinal furrows which mark off the central portion of the fascia from the lateral parts. They consequently lie one upon each side of the flexor brevis digitorum, and form partitions which separate it from the abductor hallucis on the one hand, and the abductor minimi digiti on the other. To demonstrate these septa, make a transverse incision through the central portion of the plantar fascia about an inch in front of the internal tuberosity of the os calcis, and also a longitudinal cut through the same piece of fascia, extending from the first incision along the middle line of the foot. Now raise the divided fascia and throw it outwards and inwards.

Some difficulty will be experienced in effecting this, owing to its affording a surface of origin in its upper part to the subjacent flexor brevis digitorum. As we approach the margins of this muscle the septa are brought into view.

Muscles and Tendons of the Sole.—It is customary to look upon the muscles and tendons which we find in the dissection of the sole as being disposed of in four strata, viz.:—

First layer.	Abductor hallucis. Flexor brevis digitorum. Abductor minimi digiti.
Second layer.	Tendon of flexor longus digitorum. Musculus accessorius. Lumbrical muscles. Tendon of flexor longus hallucis.
Third layer.	Flexor brevis hallucis. Adductor hallucis. Transversus pedis. Flexor brevis minimi digiti.
Fourth layer.	Interosseous muscles. Tendon of the peroneus longus. Tendon of the tibialis posticus.

Dissection.—The lateral portions of the plantar fascia should be raised from the subjacent muscles. The three superficial muscles of the sole are then exposed to view and their connections can be studied. The *flexor brevis digitorum* is placed in the middle, the *abductor minimi digiti* extends along the outer margin of the sole, and the *abductor hallucis* along the inner margin of the sole. In the interval between the abductor hallucis and flexor brevis digitorum the *internal plantar nerve* and *artery* will be found. Follow the nerve towards the toes and dissect out its four digital branches. In doing so care must be taken of the muscular twigs which are given to the flexor brevis hallucis and the innermost lumbrical muscle. Slender branches of the internal plantar artery accompany the

digital nerves. Now trace the trunk of the *internal plantar nerve* backwards, by carefully separating the flexor brevis digitorum and the abductor hallucis along the line of the internal intermuscular septum. It will be found to give a branch of supply to each of these muscles. In the next place separate the contiguous borders of the flexor brevis digitorum and abductor minimi digiti. The *external plantar artery* and *nerve* lie for a short portion of their course in the interval between these muscles. Approaching the prominent base of the fifth metatarsal bone, the artery disappears from view by turning inwards under cover of the flexor tendons. At the same point the external plantar nerve divides into its superficial and deep divisions. The *deep division* of the external plantar nerve cannot be dissected at present as it accompanies the external plantar artery. The *superficial division*, however, should now be traced to its distribution.

The Flexor Brevis Digitorum arises from the front part of the internal tubercle of the os calcis, from the deep surface of the central part of the plantar fascia, and from the intermuscular septum on either side of it. About the middle of the sole the fleshy belly divides into four slips, which end in slender tendons for the four outer toes. These enter the fibrous flexor sheaths of the toes, and will be afterwards studied.

The Abductor Hallucis takes origin from the inner aspect of the internal tubercle of the os calcis, from the internal intermuscular septum, from the lower border of the internal annular ligament, and from the lateral part of the plantar fascia which covers it. A strong tendon issues from the fleshy belly. This is joined on its outer and deep surface by fibres of the internal head of the flexor brevis hallucis, and is inserted into the inner aspect of the base of the proximal phalanx of the great toe.

Abductor Minimi Digiti.—The origin of this muscle extends inwards under cover of the flexor brevis digitorum.

The latter muscle must therefore be detached from the os calcis and turned forwards. The abductor minimi digiti is then seen to have a broad origin from both the inner and outer tubercles of the os calcis, from the external intermuscular septum, and the lateral part of the plantar fascia which covers it. Its tendon is inserted into the outer aspect of the base of the proximal phalanx of the little toe.

Dissection.—The origin of the *abductor hallucis* from the os calcis and from the internal annular ligament should be divided and the muscle turned inwards. With a little dissection the mode and place of origin of the *plantar arteries* and *nerves* will be made manifest. They are the terminal branches of the *posterior tibial artery* and *nerve*, and they arise in the hollow of the os calcis under cover of the origin of the abductor hallucis. But further, we are now in a position to trace the *external plantar artery* and *nerve* as they pass outwards upon the musculus accessorius to the point where they were first seen—viz., in the interval between the abductor minimi digiti and the flexor brevis digitorum. In following the external plantar nerve, the branches which it gives to the musculus accessorius and the abductor minimi digiti must be secured. The latter nerve lies close to the os calcis.

Internal Plantar Artery.—This is the smaller of the two terminal branches of the posterior tibial artery. It arises in the hollow between the internal malleolus and the prominence of the os calcis at the lower border of the internal annular ligament. At first it is placed under cover of the abductor hallucis, but as it proceeds forwards it appears in the interval between this muscle and the flexor brevis digitorum. Finally, at the root of the great toe it ends by joining the digital branch to the inner side of the hallux.

The *branches* which proceed from the internal plantar are small but very numerous. They are—(1) three twigs which accompany the digital branches of the internal

plantar nerve to the clefts between the four inner toes. These end by joining the corresponding digital arteries; (2) a series of cutaneous branches to the skin of the sole, which pierce the deep fascia in the furrow between the internal lateral and central parts of the plantar fascia; (3) a number of branches to the muscles in the vicinity; (4) some offsets which pass inwards under cover of the abductor hallucis to reach the inner border of the foot.

The External Plantar Artery is much larger than the internal plantar. It is accompanied by the external plantar nerve and two *venæ comites.* From its origin in the hollow of the os calcis it proceeds outwards across the sole to reach the interval between the flexor brevis digitorum and the abductor minimi digiti. In this interval it is continued forwards for a short distance, and then at the base of the fifth metatarsal bone it turns suddenly inwards, and crosses the sole a second time, under cover of the flexor tendons, to form the plantar arch. In the present stage of the dissection it is only displayed as far as the base of the fifth metatarsal bone. Between its origin and this point its relations are as follows:—(1) it is placed between the abductor hallucis and the hollow of the os calcis; (2) it lies between the flexor brevis digitorum and the musculus accessorius; (3) it occupies the interval between the flexor brevis digitorum and the abductor minimi digiti. In this latter situation it is near the surface, and is merely covered by the integument and fasciæ.

The *branches* which proceed from this part of the vessel are—(1) twigs to the neighbouring muscles; (2) *internal calcanean* branches which arise near its origin, and gain the heel by piercing the origin of the abductor hallucis; (3) cutaneous branches which appear through the deep fascia along the line of the external intermuscular septum; (4) twigs to the outer margin of the foot which anastomose with the tarsal and metatarsal branches of the dorsalis pedis.

The Internal Plantar Nerve is the larger of the two terminal branches of the posterior tibial, and it takes origin in the hollow of the os calcis under cover of the internal annular ligament. It accompanies the internal plantar artery, and presents the same relations. After it emerges from under cover of the abductor hallucis, it gives off the digital branch to the inner side of the hallux, and then ends in the interval between the abductor hallucis and the flexor brevis digitorum by dividing into three digital branches.

The *branches* of the internal plantar nerve are :—

1. Cutaneous twigs to the skin of the sole.
2. Muscular branches.
3. Four digital branches.

The *cutaneous twigs* to the integument of the sole spring from the trunk of the nerve, and pierce the deep fascia in the line of the internal intermuscular septum.

The *four digital branches* supply both sides of the hallux and of the second and third toes, and also the tibial side of the fourth toe. The *first or innermost digital nerve* goes to the inner side of the great toe. The *second* divides to supply the contiguous margins of the great toe and the second toe. The *third* deals similarly with the second and third toes; whilst the *fourth* supplies the adjacent sides of the third and the fourth toes. In its digital distribution, therefore, the internal plantar nerve closely resembles the median nerve in the hand. To the *fourth* or *outermost digital branch* a twig of communication is given by the superficial division of the external plantar nerve.

The digital nerves should be traced along the toes. They are arranged in a manner very similar to that of the corresponding nerves of the fingers.

The *muscular branches* go to four muscles of the sole, viz. the abductor hallucis, the flexor brevis digitorum, the flexor brevis hallucis, and the innermost or first lumbrical

muscle. The branches which supply the abductor hallucis and the flexor brevis digitorum arise from the trunk of the internal plantar nerve a short distance from its origin. The other two spring from the inner two digital nerves: thus, from the first digital nerve proceeds the branch to the flexor brevis hallucis; from the second, the branch to the first lumbrical.

The External Plantar Nerve corresponds to the ulnar nerve in the palm of the hand. It accompanies the external plantar artery and presents the same relations. In the interval between the abductor minimi digiti and the flexor brevis digitorum, opposite the base of the fifth metatarsal bone, it divides into a deep and a superficial part. The *deep division* follows the plantar arch under cover of the flexor tendons. The *superficial division* divides into two digital branches.

From the trunk of the external plantar nerve proceed *two muscular branches,* viz. to the musculus accessorius and to the abductor minimi digiti.

The *first or outer digital branch* of the superficial part of the external plantar nerve goes to the outer side of the little toe. It also gives muscular twigs to the flexor brevis minimi digiti and the interosseous muscles in the fourth intermetatarsal space.

The *second digital branch* divides to supply the adjacent sides of the fourth toe and little toe. It likewise sends a twig of communication to the fourth digital branch of the internal plantar nerve.

Second Layer of Muscles and Tendons.—The abductor minimi digiti should be completely detached from its origin, and turned forwards in order that a good display may be obtained of the structures composing the second stratum of the sole. As the tendon of the *flexor longus hallucis* enters the sole it grooves the under surface of the sustentaculum tali and inclines inwards towards the great toe. The tendon of the *flexor longus digitorum* on the

other hand inclines outwards to reach the middle of the foot, where it divides into four tendons for the four outer toes. Moreover, the tendons of these two muscles cross each other in the sole—the tendon of the flexor digitorum lying upon the plantar surface of the tendon of the flexor longus hallucis, and receiving from it a strong tendinous slip.*

The *musculus accessorius*, which is inserted into the tendon of the long flexor of the toes, and also the four *lumbrical muscles*, which arise from the flexor tendons, should now be cleaned. Note the position of the long plantar ligament between the two heads of origin of the accessorius.

Fibrous Flexor Sheaths.—Before tracing the flexor tendons forwards on the toes it is necessary to examine the sheaths which retain them upon the plantar aspect of the phalanges. In their construction these fibrous sheaths are precisely similar to the corresponding sheaths of the fingers. They are not so strongly marked, but they present the same thickenings over the shafts of the phalanges and the same want of strength opposite the interphalangeal joints. They may now be opened in order that the enclosed tendons may be examined. A synovial sheath is present in each to facilitate the play of the flexor tendons within them.

Insertions of the Flexor Tendons.—Two tendons, one from the flexor brevis digitorum, and one from the flexor longus digitorum, enter the flexor sheath of each of the

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* Sir William Turner has called attention to the fact that this slip, which passes from the tendon of the flexor longus hallucis to the tendon of the flexor longus digitorum, varies greatly in magnitude and in the manner in which it is connected with the flexor tendons of the toes. In the majority of cases it goes to the tendons of the second and third toes; in some cases, however, only to the tendon of the second toe, or to the tendons of the second, third, and fourth toes. Very rarely does it divide so as to bring all the tendons of the flexor longus digitorum into connection with the tendon of the flexor longus hallucis.

four outer toes. Of these, the tendon of the former muscle corresponds with a tendon of the flexor sublimis in the hand, whilst the tendon of the flexor longus digitorum corresponds with a tendon of the flexor profundus. Further they are inserted in exactly the same manner. The tendon of the flexor brevis, which is the more superficial, divides into two slips, and between these the tendon of the flexor longus proceeds forwards to its insertion into the plantar aspect of the base of the ungual phalanx. The two slips of the tendon of the flexor brevis are joined by their margins on the deep surface of the long flexor tendon, and then separate again to obtain insertion into the sides of the shaft of the second phalanx about its middle.

The Tendon of the Flexor Longus Hallucis, after giving its slip to the tendon of the flexor longus digitorum, is prolonged forwards to the great toe. On the plantar aspect of the hallux it is retained in place by a flexor sheath, and is inserted into the base of the terminal phalanx.

The Musculus Accessorius takes a course straight forwards from the heel, and acts as a direct flexor of the toes. It also tends to bring the tendons of the long flexor muscle into a line with the toes upon which they operate. It arises by two heads which embrace the os calcis and the long plantar ligament. The *inner head*, wide and fleshy, springs from the inner concave surface of the os calcis; the *outer head*, narrow, pointed, and tendinous, takes origin from the outer surface of that bone, and also from the long plantar ligament. The musculus accessorius is inserted into the tendon of the flexor longus digitorum in the middle of the sole. It is supplied by a branch from the external plantar nerve.

The Lumbrical Muscles of the foot are not so strong as the corresponding muscles in the palm of the hand. They are four in number, and arise from the tendons of the

flexor longus digitorum. The outer three lumbricals spring from the adjacent sides of the tendons between which they lie; the first or innermost muscle takes origin from the tibial side of the tendon of the long flexor which goes to the second toe. The slender tendons

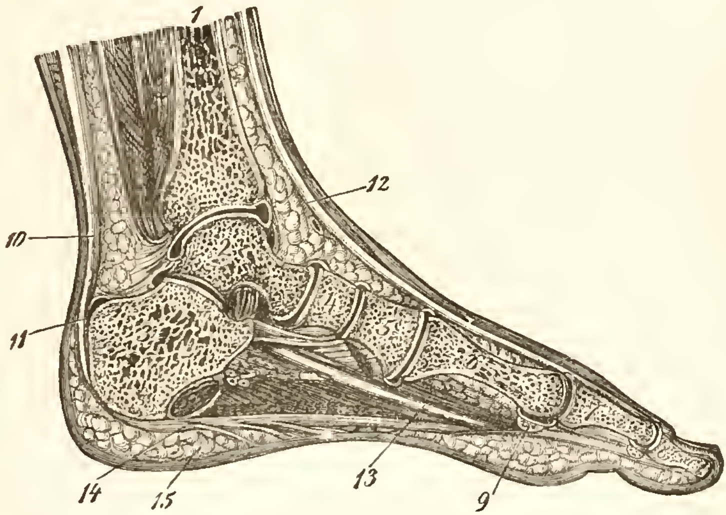

FIG. 67. (From Luschka.)

Vertical section through the Foot, along a line stretching from the centre of the heel behind to the centre of the great toe in front.

1. Tibia.
2. Astragalus.
3. Os calcis.
4. Scaphoid.
5. Internal cuneiform.
6. First metatarsal.
7 & 8. Phalanges of hallux.
9. Sesamoid bone.
10. Tendo Achillis.
11. Bursa between tendo Achillis and os calcis.
12. Tendon of extensor longus hallucis.
13. Tendon of flexor longus hallucis.
14. Plantar fascia (central part).
15. Thick superficial fascia of heel.

of the lumbrical muscles proceed to the tibial sides of the four outer toes, and are inserted into the expansions of the extensor tendon on the dorsal aspect of the proximal phalanges. The first or innermost lumbrical is supplied by the internal plantar nerve; the others by the external plantar nerve.

Third Layer of Muscles.—To bring the third layer of muscles into view we require to make the following dissection:—Divide the two heads of the accessorius and draw the muscle forwards from under the external plantar vessels and nerve. Sever also the tendons of the flexor longus digitorum and the flexor longus hallucis at the point where they emerge from under cover of the internal annular ligament. Upon cutting the branch which is given by the external plantar nerve to the accessorius these structures can be thrown forwards towards the toes. On raising the lumbrical muscles, the twigs which are furnished to the *second*, *third*, and *fourth* by the deep division of the external plantar nerve must be looked for. That for the second lumbrical muscle will be seen to take a recurrent course around the transversalis pedis muscle. Lastly, cut the internal plantar nerve close to its origin and turn it aside.

The *flexor brevis hallucis* lies along the outer side of the abductor hallucis.

The *adductor obliquus hallucis* has a very oblique position in the sole, and hides to a great extent the interosseous muscles. It lies to the outer side of the flexor brevis hallucis.

The *transversus pedis*, or *adductor transversus hallucis*, is placed transversely across the heads of the metatarsal bones.

The *flexor brevis minimi digiti* may be recognized from its lying upon the fifth metatarsal bone.

The deep division of the external plantar nerve and the plantar arch are partially exposed, but they will be more fully displayed at a later stage.

The Flexor Brevis Hallucis arises from the cuboid bone and from the slip from the tendon of the tibialis posticus muscle, which goes to the middle and outer cuneiform bones. It is narrow and tendinous at its origin, but it soon divides into two separate fleshy bellies, which are

ultimately inserted upon either side of the base of the proximal phalanx of the great toe. In the tendons of insertion two large sesamoid bones are developed. The inner head of the flexor brevis hallucis is closely connected with the tendon of the abductor hallucis, and is inserted in common with it. The flexor brevis hallucis is supplied by the internal plantar nerve.

The Adductor Obliquus Hallucis arises from the sheath of the peroneus longus muscle and from the bases of the second, third, and fourth metatarsal bones. It tapers as it approaches the root of the hallux, and is inserted, with the outer head of the flexor brevis hallucis, into the fibular aspect of the base of the proximal phalanx of the great toe. It is supplied by the deep division of the external plantar nerve.

The Transversus Pedis (adductor transversus hallucis) is a second special adductor of the great toe. It springs by a series of slips from the inferior metatarso-phalangeal ligaments, and also from the transverse metatarsal ligament, and proceeds transversely inwards under cover of the flexor tendons to find insertion into the fibular side of the base of the proximal phalanx of the great toe in common with the adductor obliquus hallucis. Its nerve of supply comes from the deep division of the external plantar.

The Flexor Brevis Minimi Digiti is a single fleshy slip, which springs from the base of the fifth metatarsal bone and the sheath of the peroneus longus tendon. It is inserted into the fibular side of the base of the proximal phalanx of the little toe. Its nerve-supply comes from the superficial division of the external plantar nerve.

Dissection.—The adductor hallucis and the flexor brevis hallucis must now be detached from their origins and thrown forwards, in order that the entire length of the plantar arch, and the deep division of the external plantar

nerve, may be displayed. In raising the adductor hallucis the branch which is given to it by the deep division of the external plantar nerve must be secured and retained.

The Plantar Arch is the continuation of the external plantar artery. It extends across the sole from the base of the fifth metatarsal bone to the posterior part of the first intermetatarsal interval, where it is joined by the dorsalis pedis artery. The plantar arch is deeply placed. it rests upon the interosseous muscles close to the bases of the metatarsal bones, and it is covered by the flexor tendons, the lumbrical muscles, and the adductor hallucis. It is accompanied by the deep division of the external plantar nerve and by two *venæ comites*.

The *branches* which proceed from the plantar arch are:—

1. Articular.
2. Posterior perforating.
3. Digital.

The *articular twigs* arise from the concavity of the arch, and run backwards to supply the tarsal joints.

The *posterior perforating branches* are three in number. They proceed upwards in the back parts of the outer three intermetatarsal spaces. Each artery occupies the interval between the heads of the corresponding dorsal interosseous muscle. They end on the dorsum of the foot by joining the three dorsal interosseous branches of the metatarsal artery.

The *digital branches* are four in number, and are arranged in the same manner as the digital branches of the superficial palmar arch in the hand. The *first* or *outermost* goes to the fibular side of the little toe; the *second* proceeds forwards in the fourth interosseous space, and divides to supply the contiguous sides of the fourth and little toes; *the third* bifurcates at the cleft between the third and fourth toes, and gives the collateral branches to their adjacent sides; and *the fourth* is disposed in a similar manner, and

furnishes collateral branches to the contiguous margins of the second and third toes.

Each of the inner three digital arteries, at its point of division, sends upwards in the interosseous space a minute *anterior perforating branch*, to join the corresponding dorsal interosseous branch of the metatarsal artery.

Upon the sides of the toes the collateral branches are distributed in exactly the same manner as the corresponding arteries of the fingers.

The Arteria Magna Hallucis (the *plantar digital branch* of the dorsal artery of the foot) corresponds with the arteria radialis indicis and the arteria princeps pollicis of the hand. It arises from the dorsal artery of the foot in the back part of the first interosseous space, and proceeds forwards to the cleft between the great toe and the second toe. Having supplied a branch to the inner side of the hallux, it divides into the collateral branches for the adjacent sides of the great toe and the second toe.

The Deep Division of the External Plantar Nerve accompanies the plantar arch in its inward course across the sole, and ends in the deep surface of the adductor hallucis. In addition to this muscle, it supplies all the interosseous muscles, with the exception of those in the fourth space, the transversus pedis, and the *three* outer lumbrical muscles (Brooks). The twig to the second lumbrical takes a recurrent course around the anterior border of the transversus pedis.

Transverse Metatarsal Ligament.—The transversus pedis should now be detached from its origin, and thrown inwards towards the hallux. This brings into view the transverse metatarsal ligament—a strong fibrous band which stretches across the heads of the five metatarsal bones. It is attached to the anterior ligaments of the metatarso-phalangeal joints. It differs from the corresponding ligament of the hand, inasmuch as it includes within its grasp the metatarsal bone of the hallux.

Fourth Layer of Muscles.—A satisfactory display of the *interosseous* muscles cannot be obtained unless the transverse metatarsal ligament be divided between the heads of the metatarsal bones. The toes can now be separated more freely from each other, and the interosseous muscles traced to their insertions. It is well also to reflect at this stage the flexor brevis minimi digiti.

The *plantar interosseous muscles* are three in number, and are so placed that they adduct the three outer toes towards a line drawn through the second toe. They arise from the plantar aspects of the outer three metatarsal bones, and are inserted one upon the tibial side of each of the corresponding toes. The *dorsal interosseous muscles* are four in number. They occupy the four intermetatarsal spaces, and consequently they must be dissected both upon the plantar and dorsal aspects of the foot. They are arranged so as to abduct the four outer toes from a line drawn through the second toe. They are inserted, therefore, as follows :—*the first* upon the tibial side of the second toe; *the second* upon the fibular side of the same toe; *the third* upon the fibular side of the third toe; and *the fourth* upon the fibular side of the fourth toe. The slender tendons of the interosseous muscles are only very slightly attached to the bases of the proximal phalanges. They are for the most part inserted into the expansions of the extensor tendons on the dorsal aspect of the toes.

Tendons of the Tibialis Posticus and Peroneus Longus.—Before leaving the sole the dissector must determine the precise insertions of the tendons of the tibialis posticus and the peroneus longus. The tendon of the *tibialis posticus* is not merely inserted into the tubercle of the scaphoid. Fibrous slips are seen to spread out from it, and these may be traced to every bone of the tarsus with the exception of the astragalus, and also to the bases of the second, third, and fourth metatarsal bones. As it lies under the head of the astragalus, the tendon of the

tibialis posticus has developed within it a sesamoid nodule of fibro-cartilage, or perhaps a sesamoid bone.

The tendon of the *peroneus longus* turns round the outer margin of the foot, and runs inwards in the groove on the under surface of the cuboid bone across the sole, to reach the base of the first metatarsal bone. As it traverses the sole it is enclosed in a fibrous sheath. This sheath is mainly formed by fibres derived from the long plantar ligament. Open the sheath and its smooth, glistening, internal surface will be displayed. This appearance is due to the synovial membrane which lines it. The tendon is inserted into the inferior part of the base of the first metatarsal bone, and also to a slight degree into the adjacent part of the internal cuneiform bone. It likewise, in some cases, sends a slip to the base of the second metatarsal bone. As the tendon winds round the cuboid bone it is thickened, and contains a nodule of fibro-cartilage, or perhaps a sesamoid bone.

Dissection.—The dissection of the sole of the foot is brought to an end by sawing through the first metatarsal bone close to its base, and removing its proximal extremity. A good view is thus obtained of the continuity between the dorsalis pedis artery and the plantar arch.

Anastomosis around the Knee-joint.—The most important of the anastomoses around the knee-joint are placed on the anterior aspect of the articulation, and take the form of three transverse arches. The uppermost of these arterial arcades passes through the superficial fibres of the quadriceps extensor close to the upper border of the patella; the middle and lower are both placed under cover of the ligamentum patellæ. The middle arch runs across in the fatty tissue close to the lower end of the patella; the lower arch lies on the tibia immediately above its tubercle. The upper and middle of these transverse arches are connected, on each side of the patella, by ascending and descending branches, which

anastomose with one another, and thus enclose the patella in an irregularly quadrilateral arterial framework. From all sides of this arterial enclosure twigs are given off which enter small foramina on the anterior surface of the patella

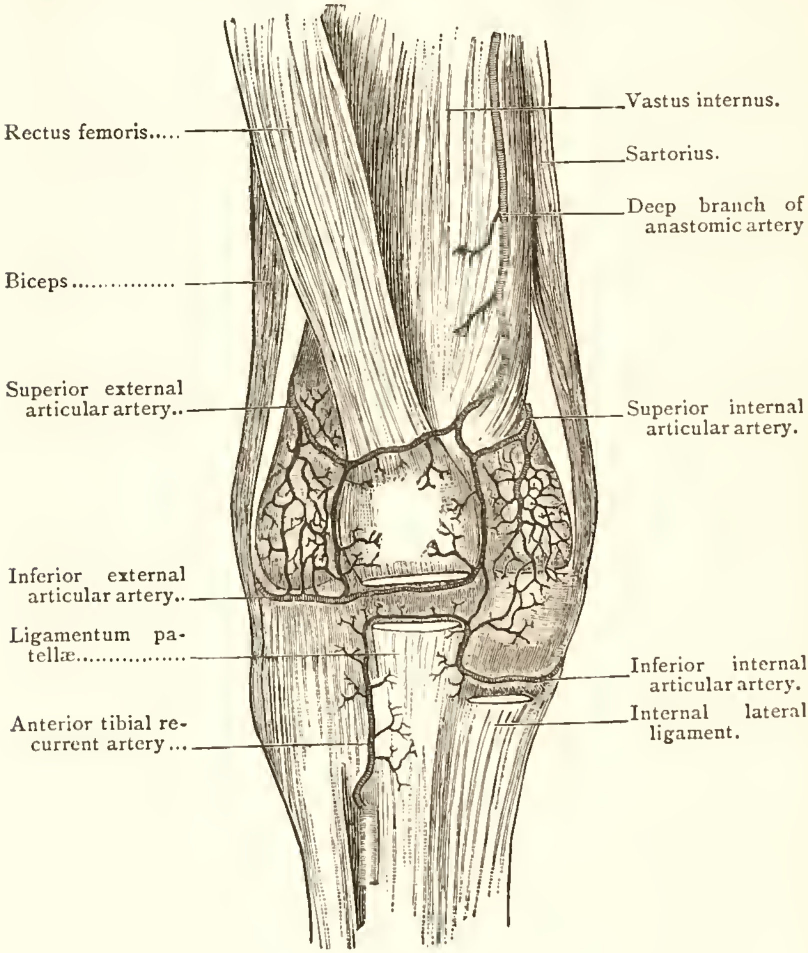

FIG. 68.

Anastomosis on the anterior aspect of the Knee-joint.

to supply the osseous substance. Six arteries take part in the formation of this system of anastomoses, viz. the deep branch of the anastomotica, the superior and inferior arti-

cular branches of the popliteal and the anterior recurrent branch of the anterior tibial.

The arteries which take part in this anastomosis may now be followed in so far as this can be done without disturbing the ligaments of the knee-joint. During the dissection of the articulation they will be fully exposed. The *deep branch* of the *anastomotica* passes downwards through the fibres of the quadriceps muscle. As it approaches the patella it becomes more superficial and bends outwards close to the upper border of that bone to anastomose with the superior external articular. Near the inner border of the patella it gives off a branch which joins a twig from the superior internal articular, and then runs downwards to inosculate with the inferior external articular, and form with that vessel the middle of the three transverse arches above described. The *superior internal articular*, after passing between the tendon of the adductor magnus and the femur, winds forwards on the bone, forms a close-meshed arterial network in the periosteum which covers the internal condyle of the femur, and supplies the adjacent part of the synovial membrane. It gives off a branch which joins the anastomotica. This branch is sometimes of considerable size, and may entirely replace the anastomotica in the formation of the middle arch. The *superior external articular* has been previously seen to quit the popliteal space by passing forwards between the tendon of the biceps and the femur. From this point it proceeds onwards, and soon divides into a superficial and a deep branch. The *superficial* branch runs inwards along the upper border of the patella, and, after communicating with an ascending branch from the inferior external articular, inosculates with the anastomotica to complete the upper arch. The *deep* branch ramifies on the external condyle of the femur, and covers it with a network similar to that which has been described on the internal condyle. The networks thus formed on the two condyles of the femur communicate with one another above the trochlear surface, and are also joined below by twigs from the external and internal inferior articular arteries.

The *inferior external articular* passes forwards between the two divisions of the external lateral ligament of the knee-joint, and runs for about an inch in close contact with the external semilunar fibro-cartilage. It then passes inwards under cover of the ligamentum patellæ to inosculate with the lower branch of the anastomotica, and form the middle arch. Before ending in the arch, it gives off a strong branch which passes upwards along the outer border of the patella to join the superior external articular. The *inferior internal articular* runs forwards on the tibia, being placed between the bone and the internal lateral ligament of the knee-joint. It then breaks up into a

number of twigs which ramify over the lower and inner part of the capsule of the knee-joint. A few of these ascend and anastomose with the inner part of the middle arch; others inosculate with the superficial division of the anastomotica, whilst one strong twig passes outwards under cover of the ligamentum patellæ to anastomose with the anterior tibial recurrent artery, and complete the inferior arch. The *anterior tibial recurrent* artery ascends through the fibres of the tibialis anticus muscle to the outer border of the ligamentum patella, and then turns inwards under cover of that structure to join the branch of the inferior internal articular last described.

The knee-joint is supplied on its posterior aspect by twigs derived from all the articular branches of the popliteal. These twigs are variable in their origin, and the anastomoses which are formed between them are unimportant and inconstant. They are sometimes supplemented by another artery, the *posterior tibial recurrent.* This small vessel is a branch of the anterior tibial before it leaves the back of the leg. It ascends under cover of the popliteus muscle, ramifies over the lower part of the ligamentum posticum Winslowii, and inosculates with the two inferior articular branches of the popliteal.

The *azygos articular artery* is chiefly destined for the supply of the interior of the joint. It pierces the posterior ligament, passes forwards between the crucial ligaments, and ramifies in the fatty tissue in that situation. Its terminal twigs usually anastomose with the middle of the three arches in front of the knee-joint. It will be dissected at a later stage in the interior of the joint.

Articular Nerves.—The knee-joint is richly supplied with nerves. No less than ten distinct branches may be traced to it. The anterior crural, the external popliteal, and the internal popliteal trunks, contribute three twigs apiece to this articulation, and the obturator furnishes a filament to its posterior aspect. The anterior crural supplies the joint through branches which proceed from the nerves to the vastus externus, vastus internus, and subcrureus. These nerves pierce the fibres of the quadriceps muscle, and are distributed to the upper and anterior part of the articulation. The articular branch from the nerve to the vastus internus is of larger size than the other two, and it accompanies the deep branch of the anastomotica artery. The external popliteal nerve gives off—(1) the superior and inferior external articular nerves: these accompany

the arteries of the same name, and end in fine filaments, which pierce the capsule of the joint; and (2) the recurrent articular nerve which accompanies the anterior tibial recurrent artery. This nerve ends chiefly in the tibialis anticus muscle; but a fine twig may reach the lower part of the anterior aspect of the knee-joint. The internal popliteal furnishes the knee-joint with superior, inferior, and azygos articular nerves, which accompany the arteries of the same name and are similarly distributed. The branch from the obturator nerve descends on the posterior aspect of the popliteal artery as far as the back of the knee-joint. At this point it leaves the artery and, inclining forwards, breaks up into several filaments which separately pierce the posterior ligament.

ARTICULATIONS.

The dissection of the knee-joint, the ankle-joint, the tibio-fibular joints, and the various articulations of the foot, may now be proceeded with. It is possible that the ligaments may have become hard and dry. If this be the case, soak the joints in water for an hour or two.

Knee-joint.—In this joint three bones are in apposition, viz. the lower end of the femur, the upper end of the tibia, and the patella. It is the largest and most complicated articulation in the body; and if the bones be examined in the skeleton, the joint presents an apparent insecurity, because the bony surfaces show little adaptation the one to the other. In reality, however, it is very strong, and very rarely suffers dislocation on account of the strength of the ligaments which retain the bones in place. The ligaments on the outside of the knee-joint are :—

1. The capsular ligament.
2. Two lateral ligaments—external and internal.
3. The ligamentum patellæ (or anterior ligament).
4. The posterior ligament.

Dissection.—The popliteal vessels and nerves, and the muscles surrounding the knee-joint, must be removed. Portions of the tendons of the biceps, semimembranosus, sartorius, semitendinosus, gracilis, and popliteus, together with small pieces of the heads of the gastrocnemius, should be left in place in order that their connection with the ligaments of the joint may be studied. The quadriceps extensor may be divided about three inches above the patella, and the lower part allowed to remain in position. Further, the various articular arteries which surround the joint should be followed to their terminations.

The Capsule of the knee-joint, together with the internal and posterior ligaments, form a complete investment for the articulation. In the upper and front part of the joint it is deficient, but here its place is taken by the common tendon of the quadriceps extensor muscle. The capsule may be regarded as an aponeurotic expansion on the front of the articulation, which fills up the intervals between the two lateral and the anterior ligaments. The fascia lata and expansions from the surrounding tendons enter into its formation. Thus on the outer aspect it is largely composed of the ilio-tibial band of fascia lata as this proceeds downwards to its attachment to the tibia. Traced backwards, the capsule will be seen to be prolonged over, and to hide from view, the external lateral ligament. It also covers the ligamentum patellæ, and on the inner side of the limb receives expansions from the sartorius and semimembranosus, and finally fuses with the internal lateral ligament.

The Ligamentum Patellæ forms the anterior ligament of the knee-joint, and constitutes at the same time the tendon of insertion of the quadriceps extensor muscle. By the removal of the capsular expansion from its surface it may be fully exposed and its margins defined.

The *ligamentum patellæ* is a strong band, about two inches long, which is attached above to the inferior angle

and lower border of the patella, and below to the lower part of the anterior tubercle of the tibia. Its superficial fibres are directly continuous over the surface of the patella with the central part of the common tendon of the quadriceps extensor. Its deep surface rests upon the infrapatellar pad of synovial fat, and upon a small bursa which intervenes between it and the upper part of the anterior tubercle of the tibia. The two lower arterial anastomotic arches of the knee are placed under cover of it.

The External Lateral Ligament may be exposed by removing the part of the capsule which is formed by the ilio-tibial band of fascia lata, and the prolongation which this gives backwards over the ligament. By this proceeding the inferior external articular artery will be displayed as it extends forwards to the front of the joint.

The *external lateral ligament* is rounded and cord-like. It stands well away from the joint, and is attached above to a tubercle on the outer tuberosity of the femur. Below, it is fixed to a depression on the head of the fibula in front of the styloid process. It is closely associated with the tendon of the biceps and the tendon of the popliteus. It splits the tendon of the biceps into two pieces, and extends vertically downwards to its fibular attachment between them. The tendon of the popliteus takes origin from the outer tuberosity of the femur below and in front of the femoral attachment of the external lateral ligament. As it proceeds backwards it is placed under cover of the ligament.

An additional slip is sometimes described as the *posterior part* of the external lateral ligament. When present it is attached to the femur, under cover of the outer head of the gastrocnemius, in connection with the posterior ligament. Below, it is implanted into the styloid process of the fibula.

The Internal Lateral Ligament is a long flat band, broader in the middle than at either extremity, which

springs from the inner tuberosity of the femur below the adductor tubercle. As it descends it inclines slightly forwards, and finally it gains attachment to the upper part of the shaft of the tibia below the internal tuberosity. The main part of the tendon of the semimembranosus extends forwards under cover of its posterior border to gain an insertion into the tuberosity of the tibia, whilst lower down the inferior internal articular vessels are carried forwards between it and the bone. The tendons of the sartorius, gracilis, and semitendinosus, lie upon its superficial surface, but are separated from it by an intervening bursa.

The Posterior Ligament (Ligamentum Posticum Winslowii) is very largely derived from the tendon of the semimembranosus, which sends a strong expansion over the back of the joint. It stretches from the external to the internal lateral ligament. Above, it is fixed to the upper margin of the intercondyloid notch, whilst on either side it becomes incorporated with the corresponding head of the gastrocnemius. Below, it is attached to the posterior border of the upper end of the tibia.

The posterior ligament presents a number of apertures for the entrance of blood-vessels and nerves into the interior of the joint. Of these vessels the azygos artery is the most conspicuous. In addition to these, an opening may sometimes be observed over the upper part of the internal condyle of the femur. Through this protrudes a pouch of synovial membrane which forms a bursa under the inner head of the gastrocnemius. As a rule, however, this bursa is independent of the knee-joint, and the aperture in the ligament is absent. Another opening is situated in the outer part of the ligament, and gives exit to the tendon of the popliteus, which, as we have already noted, arises under cover of the external lateral ligament.

Interior of the Joint.—A vertical incision should be made into the joint on either side of the patella and liga-

mentum patellæ, in order that the common extensor tendon and the patella may be thrown downwards over the upper end of the tibia. The joint is now opened from the front, and the parts in the interior may be observed. First note the great pad of soft fat which is placed on the deep sur-

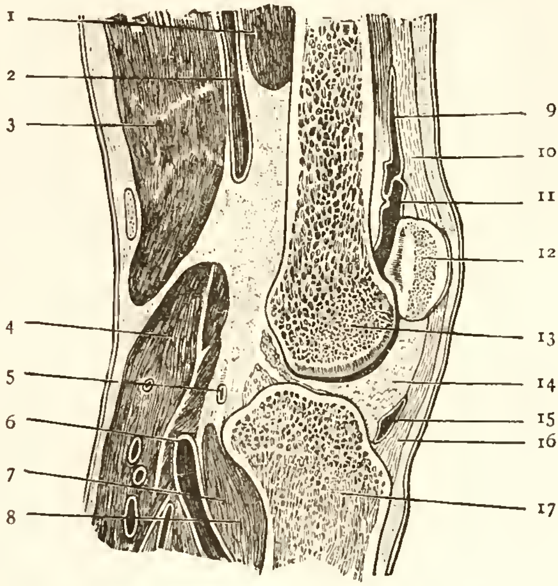

FIG. 69.

Vertical antero-posterior section through the Knee-joint.

1. Adductor magnus.
2. Popliteal artery.
3. Semimembranosus.
4. Inner head of gastrocnemius.
5. Inferior internal articular artery.
6. Popliteal vein.
7 & 8. Popliteus.
9. Synovial bursa.
10. Common tendon of quadriceps.
11. Synovial membrane.
12. Patella.
13. Femur.
14. Infra-patellar pad of fat.
15. Bursa.
16. Ligamentum patellæ.
17. Tibia.

face of the ligamentum patellæ. In vertical section this fatty mass is triangular in form (Fig. 69). It is termed the *infrapatellar pad*, and it fills up the interval between the patella, femur, and tibia, and adapts itself to the varied forms which this recess adopts in the different movements

of the joint. Towards the interior of the joint it is covered by synovial membrane, and from its surface a band of this membrane extends backwards and upwards to the intercondyloid fossa of the femur, where it is attached. This band is termed the *ligamentum mucosum.* As it approaches the femur it becomes narrow and slender; but, before it fairly rises from the surface of the infra-patellar pad, it is broad and triangular, and presents two free margins which receive the name of *ligamenta alaria.* It must be clearly understood that these are not ligaments in the ordinary sense of the word, but merely folds of synovial membrane.

Within the joint the dissector is now able to recognize:

1. The two crucial ligaments.
2. The two semilunar cartilages.

Synovial Membrane.—This is the most extensive membrane of the kind in the body. It lines the deep surface of the ligamentous structures which surround the joint, and extends upwards for at least an inch beyond the articular surface of the femur, in the form of a great *cul-de-sac*, under cover of the common tendon of the quadriceps. By its upper part this pouch usually communicates by an orifice of greater or less width with a large bursa which lies at a higher level upon the front of the femur. The synovial membrane covers both surfaces of the semilunar cartilages, gives a partial investment to the crucial ligaments, and contributes a pouch-like prolongation along the tendon of the popliteus. The synovial investment of the crucial ligaments is not complete, and is carried forwards upon them from the posterior wall of the joint. The prolongation upon the tendon of the popliteus extends downwards between the external semilunar cartilage and the back part of the upper end of the tibia. It facilitates the play of the tendon over that bone, and comes very close to the upper part of the superior tibio-fibular

joint. Indeed the synovial membrane of this joint may, in some cases, be found continuous with it.

Dissection.—Divide the ligamentum mucosum and remove the infra-patellar pad of fat. The bursa between the ligamentum patellæ and the upper part of the anterior tubercle of the tibia may now be opened and examined. Next dissect away the posterior ligament of the joint and trace the azygos articular artery, which pierces it, forwards to the crucial ligaments. It will now be seen that the posterior surface of the posterior crucial ligament is not covered by synovial membrane, and that it is connected by areolar tissue to the deep surface of the posterior ligament. Define the attachments of the crucial ligaments by removing the synovial membrane which is wrapped round them and the areolar tissue in connection with them. The semilunar cartilages should also receive the attention of the dissector, and the manner in which their fibrous pointed extremities are fixed to the tibia must be studied. At this stage the changes produced in the degree of tension of the crucial ligaments, and the change brought about in the position of the semilunar cartilages by movements of the joint, should be examined.

Movements at the Knee-joint.—The movements of the knee-joint are those of flexion and extension. The leg can be bent back until the prominence of the calf comes into contact with the posterior aspect of the thigh; but in extension the movement is brought to a close when the leg comes into a line with the thigh. In this position the joint is firmly locked, and the anterior crucial, the lateral, and the posterior ligaments being fully stretched, the leg and thigh are converted into a rigid column of support. In flexion, however, the lateral and posterior ligaments are relaxed, and a certain amount of rotation of the tibia upon the femur is allowed.

But the movements of flexion and extension at the knee-joint are by no means so simple as at first sight they might appear to be, and to obtain some appreciation of them it is necessary to subject the opposed articular surfaces to a close scrutiny. Flex the joint acutely, and examine the cartilage-covered surface of the lower end of the femur. It consists of an anterior trochlear portion for the patella, and two

condylar surfaces which move on the tibia. The trochlea is separated from the surface of the external condyle by a faintly marked groove, which takes a slightly-curved course from the external border of the lower end of the femur inwards and backwards to the fore part of the intercondyloid fossa. At either extremity this groove widens out into a distinct depression. In full extension the outer depression rests upon the anterior part of the external semilunar cartilage, whilst the inner depression rests upon the anterior border of the external tubercle of the spine of the tibia, and upon the anterior and inner uncovered free border of the condylar surface of the tibia (Bruce Young). The line of demarcation between the trochlea and the lower surface of the internal condyle of the femur is not so distinct. Close to the inner margin of the bone there is a depression which, in full extension, rests upon part of the anterior horn of the internal semilunar cartilage (Bruce Young); but external to this the trochlear surface is prolonged backwards for a certain distance along the anterior and inner margin of the intercondyloid fossa. A portion of the internal condyle is thus included in the trochlear surface, the portion skirting the inner border of the anterior part of the intercondyloid fossa, and this is termed the 'crescentic facet' of the internal condyle.

The deep surface of the patella may next be examined, and its movements in connection with flexion and extension of the knee-joint studied. A high vertical ridge divides its deep surface into a large external and a smaller internal area. Each of these is still further subdivided by faint ridges in the cartilage which coats the surface. A faint line upon the inner area of the patella descends in a vertical direction so as to mark off a narrow strip close to the inner border of the bone. This strip is called the *internal perpendicular facet.* Two horizontal lines extend outwards from the outer border of the internal perpendicular facet to the outer border of the bone, and subdivide the remainder of the inner area and the whole of the outer area into three facets each. In a well-marked patella, therefore, the deep cartilage-covered surface shows seven facets, viz. an upper pair, an intermediate pair, a lower pair, and an internal perpendicular facet (Goodsir).

The facetted appearance of the deep surface of the patella indicates that in the movements of this bone upon the trochlear surface of the femur the entire articular surface is never in contact with the femur at the same time. In flexion and extension of the knee, the patella moves downwards and upwards in a curved path, the concavity of which looks upwards, backwards, and outwards. The different facets come into contact and break contact with the femur in regular succession. Let us suppose the knee-joint to be acutely flexed: in this condition of the limb the internal perpendicular facet of the patella rests upon the crescentic facet of the internal condyle of the femur, while the outer of

the two upper patellar facets is in contact with the outer lip of the trochlear surface of the femur. No part of the patella touches the inner lip of the trochlear surface. As the leg is moved from the fully flexed to the fully extended position, the two upper facets, then the two intermediate facets, and, lastly, the two lower facets, come successively into contact with the trochlear surface of the femur (Goodsir). In figure 69 the position of the patella in the fully extended knee is exhibited.

Now examine the condylar surfaces of the femur. The posterior two-thirds of the internal condyle will be seen to be of equal extent with, and parallel to, the external condyle. The anterior third of the internal condyle, however, turns obliquely outwards to join the trochlear surface. The external condylar surface has no part corresponding with this, and its presence in connection with the internal condyle gives rise to the 'screw-home' movement, which is so characteristic of the knee-joint when fully extended. At the commencement of flexion and at the completion of extension there is a screw movement, or a movement of rotation of the tibia and femur on each other. As the leg is moved forwards from the condition of acute flexion, the condyles of the femur roll and glide over the surfaces on the upper end of the tibia until the surface of the external condyle, and the corresponding part of the internal condyle, are exhausted. This movement of the femoral condyles has been compared to that of 'a wheel partially restrained by a drag.' (Goodsir). Any additional movement beyond this point must necessarily take place in connection with the anterior oblique third of the internal condyle. This produces a rotation or screw-like motion of the femur inwards. The internal condyle travels round the spine of the tibia, and the anterior part of the intercondyloid notch comes into contact with the anterior crucial ligament and the internal tubercle of the tibial spine (Bruce Young). The joint is now 'screwed home' or locked. In the initial stage of flexion the reverse movement must be accomplished. The unlocking of the joint can only be brought about by a rotation inwards of the tibia, or a rotation outwards of the femur.

In the erect attitude of the body the line of gravity falls in front of the centre of motion in the joint. In this position, as we have seen, the joint is locked, and the posterior, lateral, and anterior crucial ligaments are tense. The limb is converted into a rigid column, and the upright posture is thereby maintained with the smallest possible degree of muscular exertion.

The muscles which operate upon the bones of the leg so as to produce flexion and extension of the limb at the knee-joint are:—(1) *extensors*, the four parts of the quadriceps extensor; (2) *flexors*, the biceps, popliteus, sartorius, gracilis, semitendinosus, and semi-

membranosus. Of these, only one is inserted on the outer side of the limb, viz. the biceps. The other five are inserted into the tibia on the inner side of the leg. This preponderance of muscles attached to the inner aspect of the leg is, no doubt, associated with the fact that the first act in flexion is the unlocking of the joint by the rotation of the tibia in an inward direction.

Dissection.—In order to obtain a proper view of the attachments of the crucial ligaments the following dissection should by made :—The femur must be sawn across about two inches above the lower articular surface. When this is done the saw should be applied to the cut surface of the lower part of the bone, and a vertical cut made through it so as to divide it into a right and a left lateral portion. The saw-cut should be planned to end inferiorly in the intercondyloid fossa between the condyles and the upper attachments of the two crucial ligaments. By this procedure the crucial ligaments can be studied singly, or together, and their relation to the lateral ligaments of the joint can be examined. It will be seen that the external lateral ligament and the anterior crucial ligament, constitute a pair of ligaments appropriated by the external condyle, to either side of which they are fixed ; while the internal lateral and the posterior crucial ligaments belong to the internal condyle of the femur, and are attached on either side of it. When this relationship is observed, the internal lateral ligament may be divided. This will, in a measure, set free the internal condyle, and give greater space for the study of the crucial ligaments.

The Crucial Ligaments are well named, because they cross each other like the limbs of the letter X in the interval between the two condyles of the femur. This crucial arrangement is seen whether they are viewed from the side, by the removal of the lower part of one condyle, or from the front or the back of the joint. The anterior crucial ligment is attached to the external condyle, whilst the posterior is fixed to the internal condyle of the femur.

They are consequently sometimes termed *external* and *internal*.

The *anterior crucial ligament* springs from the intermediate rough area on the upper surface of the tibia, immediately in front of the inner tubercle which surmounts the tibial spine. From this it proceeds upwards, backwards, and outwards, to gain attachment to the posterior part of the inner surface of the external condyle of the femur.

The *posterior crucial ligament* springs from the posterior sloping part of the intermediate rough area on the upper surface of the tibia, behind the tibial spine, and behind also the attachments of the posterior horns of both semilunar cartilages. It proceeds upwards, forwards, and somewhat inwards, and crossing the anterior crucial ligament, is attached to the outer surface of the anterior oblique portion of the internal condyle. It receives one, or sometimes two, strong slips from the posterior horn of the external semilunar cartilage.

The anterior crucial ligament is tight in extension, and the posterior crucial ligament is tight in flexion of the knee-joint.

Semilunar Cartilages.—These are two crescentic plates of fibro-cartilage which are placed on the condylar surfaces of the tibia. They deepen the surfaces upon which the condyles of the femur roll, and, being movable, they fill up the gaps which would otherwise arise during the movements of the joint. Each cartilage presents two fibrous extremities, or horns, which are attached to the rough intermediate surface on the upper end of the tibia. They are thick towards the circumference of the joint, but thin away to a fine free concave edge in the opposite direction. Both surfaces are smooth and covered with synovial membrane. They do not cover the entire extent of the condylar surfaces of the tibia. The central parts of the latter, as well as the sloping surfaces of the tubercles of the tibial spine, are free. On raising the cartilages from the

surface upon which they rest, distinct impressions similar in shape and extent are seen on the subjacent encrusting cartilage of the tibia. Carefully define the attachments of the fibrous horns of the semilunar cartilages.

The *external semilunar cartilage* is usually somewhat thicker around its circumference than the internal cartilage. It forms the segment of a smaller circle, and its horns being fixed to the tibia close together, the circle is very nearly complete. The anterior fibrous horn is attached, immediately in front of the tibial spine, to the outer side of and partly under cover of the attachment of the anterior crucial ligament. The posterior horn is fixed to the summit of the tibial spine in the interval between the two tubercles. It likewise gives a strong slip to the posterior crucial ligament. The external lateral ligament is not in contact with the external semilunar cartilage. It is separated from it by the tendon of the popliteus, and the impress of the tendon is left on the cartilage in the form of a faint smooth groove on its outer and posterior border. Behind, its circumference is attached to the posterior ligament.

The *internal semilunar cartilage* is semicircular in form, and forms the segment of a much larger circle than the external cartilage. Its anterior fibrous horn is fixed to the fore part of the intermediate rough area of the tibia in front of the attachment of the anterior crucial ligament; its posterior horn is attached to the back part of the intermediate rough area of the tibia, behind the tibial spine, and in front of the attachment of the posterior crucial ligament. The circumference of this cartilage is closely connected with the deep surface of the internal lateral ligament.

The Transverse Ligament is a fibrous band which stretches across from the fore part of one semilunar cartilage to the corresponding part of the other, constituting thereby a bond of union between them.

Attachment of Parts to Upper Surface of the Tibia.— The condyles of the femur should now be detached by dividing the external lateral ligament and the crucial ligaments close to their femoral attachments. The ligamentous structures are attached to the intermediate area on the upper surface of the tibia in the following order from before backwards :—(1) The anterior horn of the internal semilunar cartilage on the inner side of the extreme anterior part of the area. (2) The anterior crucial ligament, and the anterior horn of the external semilunar cartilage: these are placed side by side, but the attachment of the former, which lies to the inner side, overlaps that of the external semilunar cartilage. (3) The posterior horn of the external semilunar cartilage on the summit of the tibial spine between its two tubercles. (4) The posterior horn of the internal semilunar cartilage immediately behind the tibial spine. (5) The posterior crucial ligament at the hinder part of the area.

The Ankle-joint is a diarthrodial articulation of the ginglymus or hinge variety. It is placed between the bones of the leg and the astragalus, and the weight of the body is transferred through it to the foot. It is a joint of great strength ; its stability being ensured not only by the powerful ligaments which surround it, but also by the close interlocking of the articulating surfaces.

The bones which enter into the formation of the ankle-joint are the lower ends of the tibia and fibula and the superior surface of the astragalus. The lower ends of the leg bones are very firmly united together by an interosseous and other ligaments which give the joint a certain amount of elasticity or spring. They form a deep hollow resembling a mortice. The upper surface of the astragalus is received into this cavity.

The ligaments of the ankle-joint are:

1. The anterior.
2. The posterior.
3. The external lateral.
4. The internal lateral.

Dissection.—The remains of the annular ligaments, together with the tendons which are in relation to the joint, should be removed and the ligaments defined. The anterior and posterior ligaments should be first dissected. They may then be removed in order to bring the powerful external and internal lateral ligaments more fully into relief, and at the same time display the articulating surfaces, and thus permit the play of these surfaces to be seen when the joint is flexed and extended.

The Anterior and Posterior Ligaments are feeble bands which are placed in front of and behind the joint. They are attached to the margins of the articulating surfaces, except in front and below, where the anterior ligament is fixed to the neck of the astragalus. The fibres of these ligaments have for the most part a transverse direction.

The External Lateral Ligament is divided into three distinct bands—an anterior, a middle, and a posterior. The *anterior fasciculus* is a flattened band which passes from the anterior border of the lower end of the fibula to the outer and back part of the neck of the astragalus. The *middle fasciculus*, round and cord-like, passes from a point a little in front of the tip of the external malleolus to the external surface of the calcaneum. The *posterior fasciculus*, the strongest of the three, is a powerful band of fibres which proceeds almost horizontally inwards from the deep pit behind the lower articular surface of the fibula to a prominent tubercle on the back of the astragalus.

This tubercle is sometimes detached, and forms a supernumerary tarsal bone which may represent the *os trigonum* found in some mammals. In such cases it has been mistaken for a fracture.

The Internal Lateral or Deltoid Ligament is of a triangular form. Its apex is directed upwards and is attached to a shallow pit on the under border of the inner malleolus. Its fibres diverge as they descend, and are attached in a continuous layer from before backwards to the scaphoid,

astragalus, sustentaculum tali, and behind this to the astragalus again.

The Synovial Membrane lines the ligaments above described, and sends a small process upwards between the tibia and fibula. It is thrown into a transverse fold in front, when the joint is flexed, and into a similar fold behind when the joint is extended.

Articular Surfaces.—The lower articular surface of the tibia is irregularly quadrilateral, longer externally than internally and wider in front than behind. It is prolonged into the articular surface of the inner malleolus, which looks outwards and slightly downwards. The articular surface on the lower end of the fibula (external malleolus) is larger than the corresponding surface on the internal malleolus, and looks inwards and slightly downwards. The upper surface of the astragalus is strongly convex from before backwards. The radius of its curve taken in the long axis of the foot is 17 to 21 mm. in length. It forms an arc of 120° (Henle). It is slightly concave from side to side. The anterior portion is broader than the posterior. Laterally this surface is continued into the two facets for the malleoli. The outer of these extends lower than the inner and is triangular, with the apex pointing downwards. The inner is semilunar in form, and is confined to the upper part of the bone.

Movements.—The movements which take place at the ankle-joint are—(1) flexion (dorsal-flexion); (2) extension (plantar-flexion); and (3) a very limited degree of lateral movement (abduction and adduction) when the foot is fully extended. The two principal movements (flexion and extension) take place around a horizontal axis, which is not transverse, but which is directed outwards and backwards, so that it is inclined to the median plane of the body at an angle of about 60° (Krause). This horizontal axis passes through or near the interosseous canal between the os calcis and astragalus (Henle). As the articular cavity formed by the tibia and fibula, and also the part of the astragalus which plays in it, are broader in front than behind, it follows that the more completely the ankle-joint is flexed the more tightly will the astragalus be

grasped between the two malleoli. In the erect position the astragalus is held firmly in the bony socket, and portions of its articular surface project both in front of and behind the tibia. The centre of gravity is placed in front of the ankle-joint, and in this way the bones are kept firmly locked. When, on the other hand, the ankle-joint is fully extended (as when we rise on tip-toe) the narrower posterior part of the astragalus is brought into the socket, and thus a limited amount of lateral movement is allowed. In *flexion* the middle and posterior fasciculi of the external lateral ligament, the greater part of the internal lateral ligament, and the posterior ligament, are put on the stretch. In *extension* the anterior fasciculus of the external lateral ligament, the anterior fibres of the internal lateral ligament, and the anterior ligament, are rendered tense.

The Muscles principally concerned in producing dorsi-flexion of the foot at the ankle-joint are the tibialis anticus and the peroneus tertius; those which operate as plantar flexors are the superficial muscles of the calf, the tibialis posticus, and the peroneus longus and brevis.

Tibio-fibular Joints.—The fibula articulates with the tibia by both its upper and lower extremity. Each of these joints is provided with a synovial membrane and possesses its own appropriate ligaments. The interosseous membrane which occupies the interval between the shafts of the bones may be regarded as a ligament common to both joints. Preparatory to the examination of the tibio-fibular joints the foot must be removed by dividing the internal lateral ligament and the three parts of the external lateral ligament of the ankle-joint. The muscles must also be detached from both aspects of the interosseous membrane and the bones of the leg. The ligaments may now be defined.

Interosseous Membrane.—This is a strong membrane which stretches across the interval between the two bones of the leg, and greatly extends the surface for the origin of muscles. It is attached on the one hand to the external border of the tibia, and on the other to the interosseous ridge which descends on the internal surface of the fibula. It is composed of strong oblique fibres, which take a direction downwards and outwards from the tibia to the fibula.

An oval opening in its upper part, immediately under the external tuberosity of the tibia, is present for the passage of the anterior tibial vessels, whilst a small aperture a short distance above the ankle-joint marks the point where the membrane is pierced by the anterior peroneal artery.

Superior Tibio-fibular Joint.—At this joint the bones are held in apposition by an *anterior* and a *posterior ligament*, which pass from the outer tuberosity of the tibia downwards and outwards to be attached to the head of the fibula. The posterior ligament is the weaker of the two, and upon its upper part the tendon of the popliteus with its synovial investment rests. This investment is a prolongation from the synovial membrane of the knee-joint, and in some cases it will be found to be directly continuous with the synovial membrane which lines the superior tibio-fibular joint.

The relation of the tendon of the biceps to this joint must not be lost sight of. Attached for the most part to the head of the fibula, its fibres stretch over the front of the joint. Some of its tendinous fibres also obtain insertion into the outer tuberosity of the tibia. Firm support is in this way contributed to the superior tibio-fibular joint.

The Inferior Tibio-fibular Joint is constructed upon a stronger plan, because upon its security the strength of the ankle-joint very largely depends. Only a very narrow strip of the lower part of each of the opposing surfaces of the bones is articular and coated with cartilage. Above this, the surfaces are rough, and are held together by an exceedingly strong *interosseous ligament*, composed of short fibres which pass directly between the bones.

In addition to this interosseous ligament there are:

1. An anterior ligament.
2. A posterior ligament.
3. An inferior transverse ligament.

The *anterior and posterior ligaments* are flat strong bands which pass from the tibia to the fibula, in an oblique direction, outwards and downwards.

The *inferior ligament* lies under cover of the lower part of the posterior ligament, and to see it properly the latter should be divided. It is a strong narrow band of yellowish fibres, which takes a transverse course on the back of the joint and is firmly attached to both tibia and fibula, filling up the interval between them.

Dissection.—To see the interosseous ligament of the inferior tibio-fibular joint the bones of the leg may be sawn through about two inches above the lower end of the tibia, and then divided with the saw from above downwards in a vertical-transverse, or coronal direction. This cut should be planned so as to pass through the inferior tibio-fibular joint. The short strong fibres of the interosseous ligament will then be seen, and also the short narrow articular interval between the lower portions of the opposing surfaces of the bones. The synovial membrane which lines this is a continuation upwards of the synovial membrane of the ankle-joint.

The Articulations of the Foot.—The articulations of the foot are very numerous. They consist of:

1. The *tarsal*, *tarso-metatarsal*, and the *inter-metatarsal joints*—a series of diarthrodial articulations, the majority of which permit only a very limited degree of movement.
2. The *metatarso-phalangeal joints.*
3. The *interphalangeal joints.*

The bones which enter into these articulations are the seven tarsal bones, the metatarsal bones, and the phalanges. The tarsal and metatarsal bones are bound together by interosseous, plantar, and dorsal ligaments, and are disposed in the form of two arches, viz. a longitudinal and a transverse. The integrity of these arches is maintained partly by the tension of the ligaments and partly by the direction of the articulating surfaces of the bones.

The longitudinal arch presents a greater height and a wider span along the inner than along the outer side of the foot. The astragalus is placed on the summit of the arch and forms its keystone. The posterior pillar is short and solid, being formed by the os calcis alone; the anterior pillar, much longer, is composed of several bones, viz. the

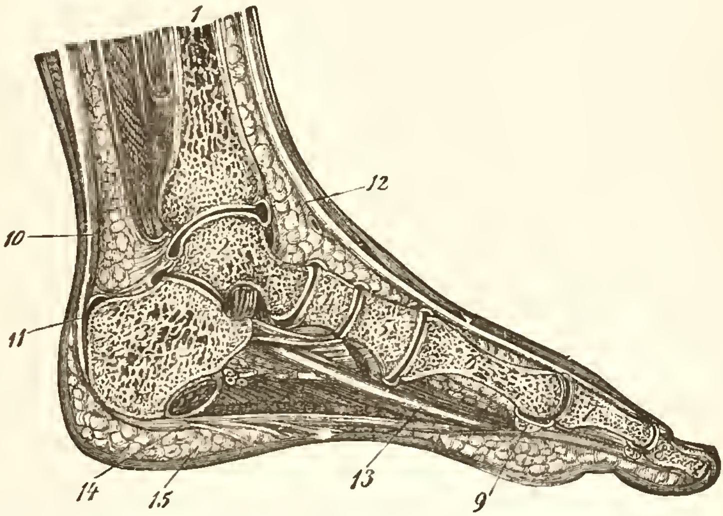

FIG. 70. (From Luschka.)

Vertical section through the Foot, along a line stretching from the centre of the heel behind to the centre of the great toe in front.

1. Tibia.
2. Astragalus.
3. Os calcis.
4. Scaphoid.
5. Internal cuneiform.
6. First metatarsal.
7 & 8. Phalanges of hallux.
9. Sesamoid bone.
10. Tendo Achillis.
11. Bursa between tendo Achillis and os calcis.
12. Tendon of extensor longus hallucis.
13. Tendon of flexor longus hallucis.
14. Plantar fascia (central part).
15. Thick superficial fascia of heel.

scaphoid, the cuboid, the three cuneiforms, and the metatarsus. Further, the anterior pillar may be considered as being formed of an inner column composed of the scaphoid, the three cuneiform, and the three inner metatarsal bones, and an outer column composed of the cuboid

and the two outer metatarsal bones. The weight of the body is transmitted to the summit of the arch through the astragalus, and the most important ligaments concerned in the prevention of too great flattening of the arch are the inferior calcaneo-scaphoid, the two plantar calcaneo-cuboid ligaments, and the various slips of the tendon of the tibialis posticus as they pass to find attachment to the different tarsal and metatarsal bones. The plantar fascia also acts powerfully in this way: connecting as it does the extremities of the two pillars of the plantar arch, it operates, as Professor Humphry has pointed out, in the same manner as the 'tie-beam' of a roof. The transverse arch of the foot is seen to best advantage across the line of the tarso-metatarsal articulations.

The muscles and tendons which have hitherto been only partially detached from the bones of the foot should now be completely removed and the ligaments defined.

Astragaloid Articulations.—The astragalus articulates by means of the large posterior facet on the under surface of its body with the corresponding posterior facet on the upper surface of the os calcis. Its head, on the other hand, is received into a large socket which is formed for it by the sustentaculum tali of the os calcis, the scaphoid, and two ligaments which pass between the os calcis and the scaphoid bone, viz. one below, the inferior calcaneo-scaphoid, and another on the outer side, the external calcaneo-scaphoid ligament. These two astragaloid articulations are quite distinct, and each is provided with a separate synovial membrane.

The ligaments which hold the astragalus in its place are four in number. Three are attached to the os calcis and one to the scaphoid bone. They are:

1. An interosseous astragalo-calcanean.
2. An external lateral astragalo-calcanean.
3. A posterior astragalo-calcanean.
4. A dorsal astragalo-navicular.

The *interosseous ligament* is by far the most powerful. It occupies the tarsal canal, and consists of strong fibres attached below to the groove between the articular facets on the upper surface of the os calcis, and above to the corresponding groove on the under surface of the astragalus.

The *external ligament* is a short band of fibres which proceeds from the outer surface of the astragalus to the outer surface of the os calcis. It is parallel with the middle fasciculus of the external lateral ligament of the ankle-joint, but it is placed on a deeper plane and lies somewhat in front of it.

The *posterior ligament* passes from the posterior border of the astragalus to the os calcis. It closes the posterior calcaneo-astragaloid articulation behind.

The *dorsal astragalo-navicular ligament* extends on the dorsum of the foot from the head of the astragalus to the scaphoid bone. It is thin and membranous.

The two lateral ligaments of the ankle-joint help to keep the astragalus in its place.

Dissection.—The astragalus should now be removed by dividing the various ligaments which hold it in place. By this proceeding the different parts which form the socket for the head of the astragalus will be brought into view; and the posterior astragalo-calcanean articulation will be seen to be completely cut off from the anterior articulation by the interosseous astragalo-calcanean ligament. The great strength of this ligament can now be appreciated, and the facets on the head of the astragalus studied. These are: (1) a convex surface which looks forwards and articulates with the scaphoid; (2) an elongated facet on its under aspect (sometimes divided into two), which rests upon the sustentaculum tali; and (3) between these, a triangular facet which corresponds with the upper surface of the inferior calcaneo-scaphoid ligament. In the recent state (and indeed usually also in the macerated condition

of the bone) these three facets are very distinctly mapped off from each other by intervening ridges.

Calcaneo-navicular Ligaments.—Although the os calcis does not directly articulate with the scaphoid bone, it is connected with it by two powerful and important ligaments, viz. an inferior and an external.

The *inferior calcaneo-scaphoid ligament* is brought into view by the removal of the astragalus. It fills up the angular gap between the sustentaculum tali and the scaphoid bone, and enters into the formation of the socket for the head of the astragalus. Its upper surface therefore is smooth and covered with synovial membrane; its lower surface is supported by the tendon of the tibialis posticus. This ligament has an important part to play in maintaining the integrity of the longitudinal arch of the foot. Posteriorly it is attached to the fore border of the sustentaculum tali, whilst in front it is fixed to the under surface of the scaphoid bone.

The *external calcaneo-scaphoid ligament* also forms a small part of the socket for the head of the astragalus. It is placed deeply in the anterior part of the depression between the os calcis and the head of the astragalus. It is composed of short fibres which are attached in front to the outer side of the scaphoid bone, and behind to the upper aspect of the fore part of the os calcis, immediately to the outer side of the facet on the sustentaculum tali. An elongated narrow facet may sometimes be noticed in correspondence with this ligament, along the posterior and outer margin of the articular surface of the head of the astragalus. In such cases four facets mark the head of the astragalus—one for each factor which enters into the formation of the socket in which it lies.

Calcaneo-cuboid Articulation.—In this joint the concavo-convex surface on the fore aspect of the os calcis articulates with the corresponding surface on the posterior aspect of the cuboid. It is a distinct joint, and is provided

with a separate synovial membrane. The *ligaments* which bind the two bones together are:

1. The inferior or plantar calcaneo-cuboid (long and short).
2. The dorsal calcaneo-cuboid.
3. The internal calcaneo-cuboid.

In the maintenance of the longitudinal arch of the foot *the plantar ligament* has an importance which is surpassed only by the inferior calcaneo-scaphoid ligament. It is disposed in two layers which are respectively termed the long and the short plantar ligaments, and which are separated from each other by some fatty areolar tissue.

The *superficial* or *long plantar ligament* springs from the under surface of the os calcis, in front of the internal and external tuberosities, and extends forwards to the inferior surface of the cuboid. Here it broadens out, and is for the most part attached to the prominent ridge on the under surface of that bone. Numerous strong fibres, however, are prolonged forwards over the tendon of the peroneus longus to find attachment to the bases of the three middle metatarsal bones. The long plantar ligament therefore extends over the greater part of the outer portion of the tarsus, and it constitutes the longest of the tarsal ligaments. Further, it forms the greater part of the sheath of the tendon of the peroneus longus muscle.

The *short plantar ligament* is placed under cover of the long plantar ligament. Slip the knife in between them, and carry the cutting edge backwards so as to detach the long ligament from the under surface of the os calcis. On throwing the detached band forwards, the short plantar ligament comes into view, and little dissection is required to make its connection apparent. It is composed of short but strong fibres, not more than an inch in length. These spring from the anterior tubercle on the under surface of the os calcis, and are attached in front to the inferior aspect of the cuboid behind its ridge. This ligament is broader than the long plantar ligament, and

is apparent along its inner border even before the latter is reflected.

The *dorsal* and *internal ligaments* connect the os calcis and cuboid bones upon the superior and inner aspects of the joint. The internal ligament, sometimes called *inter-osseous*, is to be sought for in the deep pit between the head of the astragalus and the fore part of the os calcis.

The joint between the astragalus and scaphoid bone and that between the os calcis and the cuboid bone are sometimes referred to as the 'transverse tarsal joint.' It is here that the movements of eversion in inversion of the foot chiefly take place, and it should be noted that all the ligaments which connect these two segments of the tarsus together, with the exception of one, are attached posteriorly to the os calcis. They are—

Inferior calcaneo-scaphoid, External calcaneo-scaphoid, Long plantar, Short plantar, Dorsal calcaneo-cuboid, Internal calcaneo-cuboid,	Attached behind to the os calcis.
Dorsal astragalo-scaphoid,	Attached behind to the astragalus.

Inter-cuneiform Articulations.—The three cuneiform bones are held together so firmly that very little individual movement is permitted. The chief uniting structures are *two* strong *interosseous ligaments* which pass between the non-articular portions of their opposed surfaces. These can only be seen when the bones are separated from each other. *Dorsal inter-cuneiform ligaments* are also present. These are short flat transversely-placed bands.

Scapho-cuneiform Articulation.—The three cuneiform bones articulate with the anterior surface of the scaphoid. They are held in position by *dorsal ligaments*, which pass from the dorsal surface of the scaphoid to the dorsal surface of each of the cuneiform bones, and by *plantar ligaments*, which are similarly disposed. The strength of the plantar ligaments is greater than that of the dorsal

ligaments, and they are very largely formed by slips from the tendon of the tibialis posticus.

The dissector may now divide freely all the dorsal, and the innermost of the plantar scapho-cuneiform ligaments. The scaphoid bone can then be drawn backwards so as to expose the interior of the joint. The knife may also be carried round the outer side of the external calcaneo-scaphoid ligament. A much better view of this ligament is thus obtained, although it entails the division of the dorsal scapho-cuboid ligament.

The convex anterior articular surface of the scaphoid fits into a transversely concave socket, which is formed for it by the posterior surfaces of the three cuneiform bones, and often by a small facet on the inner surface of the cuboid bone as well. The articular surface of the scaphoid is divided by prominent ridges into areas or facets corresponding with the different parts of the socket in which it lies.

The synovial membrane which lines this joint is prolonged forwards into the intercuneiform joints.

Scapho-cuboid and Cubo-cuneiform Articulations.—It has been noted that the anterior pillar of the longitudinal arch of the foot consists of an outer and an inner column. The tarsal portions of these are connected together by the scapho-cuboid and the cubo-cuneiform articulations.

It is only occasionally that the scaphoid bone touches and articulates directly with the inner surface of the cuboid bone. When it does so, the facet on the cuboid bone lies in series with the articular surfaces on the hinder ends of the cuneiform bones, and forms with them the socket for the anterior surface of the scaphoid. *The ligaments* which bind the scaphoid to the cuboid bone are disposed transversely, and consist of—(1) a series of short strong *interosseous* fibres which bind the opposed surfaces together; (2) a dorsal band; and (3) a plantar band.

The dorsal band has previously been divided in exposing

the interior of the scapho-cuneifrom joint and in defining the external calcaneo-scaphoid ligament, but the interosseous and plantar ligaments may be readily displayed.

The cuboid, by an oval facet on its inner surface, articulates with the external cuneiform bone. *Interosseous*, *dorsal*, and *plantar ligaments* bind them together. By dividing the dorsal ligament and insinuating the knife between the two bones the interrosseous ligament may be detected. It is the strongest of the three ligaments.

The synovial membrane which lines the scapho-cuneiform articulation is prolonged into the cubo-cuneiform joint and also into the scapho-cuboid joint when this exists.

Tarso-metatarsal Articulations.—The bases of the five metatarsal bones articulate with the three cuneiform bones and the cuboid bone, and are very firmly attached to them by dorsal, plantar, and interosseous ligaments.

The *dorsal ligaments* are flat distinct bands which can readily be defined. *One* such ligament passes to the base of the first metatarsal from the internal cuneiform ; *three*, one from each of the cuneiform bones, proceed to the base of the second metatarsal ; *one* extends from the external cuneiform to the base of the third metatarsal ; *two*, of which one proceeds from the external cuneiform, and the other from the cuboid, go to the base of the fourth metatarsal ; and *one* passes from the cuboid to the base of the fifth metatarsal.

The *plantar ligaments* are not so regularly disposed. Those in connection with the first and second metatarsal bones are very strong. Some of the bands have an oblique direction, and those which go to the bases of the three middle metatarsal bones are more or less connected with the sheath of the tendon of the peroneus longus, and therefore with the long plantar ligament.

To bring the *interosseous ligaments* into view, divide freely the dorsal ligaments, and then forcibly bend the metatarsus downwards upon the tarsus. The interosseous ligaments

will resist this proceeding, and on looking into the joints they will be seen stretched and tense. If the force be continued they will rupture. The interosseous ligaments are three in number, viz. an internal, a middle, and an external.

The *internal interosseous ligament* is an exceedingly strong band, which passes forwards and outwards from the anterior part of the outer surface of the internal cuneiform bone to the adjacent surface of the base of the second metatarsal bone. The *middle interosseous ligament* is small, and passes forwards between the anterior part of the inner surface of the external cuneiform and the adjacent surface of the base of the second metatarsal. The *external interosseous ligament* passes from the outer surface of the external cuneiform bone to the outer side of the base of the third metatarsal. One interosseous ligament therefore passes from each of the cuneiform bones, and of these two are attached to the base of the second, and the third to the base of the third metatarsal bone.

Tarso-metatarsal Articular Surfaces.—The manner in which the metatarsus is implanted upon the tarsus should now be examined. The first metatarsal rests upon the internal cuneiform, and this joint possesses a separate synovial membrane. The second metatarsal rests upon the middle cuneiform, but its base is grasped by the projecting anterior ends of the internal and external cuneiform bones, with both of which it articulates, and with both of which it is connected by interosseous ligaments. No wonder then that this metatarsal should possess so little power of independent movement, and present a difficulty to the surgeon when he is called upon to amputate the fore-part of the foot through the tarso-metatarsal articulations (Hey's operation). The third metatarsal rests upon the external cuneiform. The synovial membrane which lines the joints between the tarsus and the second and third metatarsal bones is continuous with that which is

present between the internal and middle cuneiform bones, and through this with the scapho-cuneiform synovial membrane. The bases of the fourth and fifth metatarsal bones are supported by the cuboid, but that of the fourth, by its inner margin, articulates also with the external cuneiform. A separate synovial membrane is present in the articulation between the two outer metatarsal bones and the tarsus.

Intermetatarsal Joints.—The bases of the metatarsal bones, with the exception of the first, articulate with each other, and are very firmly bound together.

The ligaments which connect the bases of the four outer metatarsal bones are *dorsal*, *plantar*, and *interosseous*. To bring the interosseous ligaments into view it is necessary to divide the dorsal ligaments, and then forcibly separate the bases of the bones from each other. They are strong bands which pass between the non-articular portions of the basal parts of the bones. They constitute the chief bond of union.

In addition to these basal ligaments, the strong *transverse metatarsal ligament* unites the distal extremities of the metatarsal bones. This ligament has been previously described (p. 415).

Synovial Cavities of the Foot.—There are six separate synovial cavities in connection with the tarsal, tarso-metatarsal, and inter-metatarsal articulations, viz.—(1) in the joint between the posterior facets of the astragalus and os calcis; (2) in the calcaneo-cuboid joint; (3) in the joint formed by the head of the astragalus, the scaphoid, the sustentaculum tali, and the two calcaneo-scaphoid ligaments; (4) a complicated synovial membrane which lines the scapho-cuneiform articulations, and is prolonged forwards between the cuneiforms, and also between the cuboid and external cuneiform bones. This synovial membrane, however, is not confined to the tarsus, but reaches forwards into the articulation between the second and third meta-

tarsal bones and the tarsus, as well as into the joints between the bases of the second, third, and fourth metatarsal bones;* (5) a separate synovial lining for the joint between the first metatarsal and the internal cuneiform; (6) a distinct synovial membrane for the articulations between the cuboid and the two outer metatarsal bones. This is prolonged forwards into the joint between the bases of these two metatarsals.

Metatarso-phalangeal and Interphalangeal Joints.—These joints are constructed upon a plan almost identical with that of the corresponding joints of the upper extremity. For the detailed description the student is therefore referred to p. 172. In the metatarso-phalangeal joint of the great toe the thick *inferior ligament* or *fibrous plate* holds two large sesamoid bones, which slide upon grooved surfaces on the head of the metatarsal bone.

Movements.—The movements which take place in the tarso-metatarsal, intermetatarsal, and in the majority of the tarsal joints, are simp y gliding motions. In the joints between the astragalus and seaphoid, and also between the os calcis and the cuboid, movements of a wider range are possible. It is here that the movements of *inversion* and *eversion* of the foot chiefly take place.

The first and the fifth metatarsal bones enjoy a considerable degree of mobility. The second metatarsal is so tightly grasped by the internal and external cuneiform bones, and so firmly bound to the tarsus by its basal ligaments, that only a slight degree of movement is possible.

At the metatarso-phalangeal joints, flexion, extension, abduction, and adduction, are allowed; whilst the inter-phalangeal joints only permit of flexion and extension.

In the ereet posture the parts of the foot which are chiefly coneerned in transmitting the weight of the body to the ground are the heel, the

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* The external interosseous tarso-metatarsal ligament, which passes from the external cuneiform bone (frequently from the euboid bone) to the base of the third metatarsal bone, separates the artieulations of the fourth and fifth metatarsal bones from the general tarsal articular cavity. Whether it proeeeds from the external cuneiform, or from the cuboid, it always intervenes between the opposed artieular facets on the base of the fourth metatarsal, and on the external cuneiform bone.

head of the first metatarsal bone, and the shaft of the fifth metatarsal bone. Rather more than the middle third of the inner border of the foot is raised above the ground. The outer border of the foot is more or less in contact with the ground in its entire extent, whilst the tips of the toes rest lightly on the ground. In walking—(1) the heel is brought down; (2) the sole and toes follow; (3) the heel is raised, and the weight of the body is transferred to the heads of the metatarsal bones and the toes. In the second and third parts of this operation the arches of the foot are flattened to a certain extent, but more especially in the third part of the process is the transverse arch spread out. Great elasticity is thus given to the step.

The muscles which are chiefly concerned in producing *eversion* of the foot are the three peroneal muscles; those which operate as *invertors* of the foot are the tibialis anticus and the tibialis posticus.

The *extensors of the toes* are the extensor longus hallucis, the extensor brevis digitorum, and the extensor longus digitorum. The lumbrical muscles, and the interosseous muscles, through their insertions into the extensor tendons of the four outer toes, operate as extensors of the second and third phalanges.

The *flexors of the proximal phalanges* are the lumbricales, interossei, flexor brevis hallucis, and flexor brevis minimi digiti. *The flexor of the second phalanges* is the flexor brevis digitorum; whilst the *flexors of the distal phalanges* are the flexor longus digitorum, the musculus accessorius, and the flexor longus hallucis.

Abduction and *adduction* of the toes at the metatarso-phalangeal joints are produced by the interosseous muscles, the abductor hallucis, the adductor hallucis, the transversalis pedis, and the abductor minimi digiti. The movements of abduction and adduction take place with reference to a line drawn through the second toe.

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